Phase 2 – Scoping Study

Bundaberg Regional Council

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1 INTRODUCTION

1.1 Background to Coastal Hazard Adaptation Planning

Over the last few years, the Queensland coast (and specifically the Bundaberg Region) has experienced disasters which have resulted in significant economic costs and societal impacts. In response, Bundaberg Regional Council has pro-actively developed a unique perspective on the concepts of, approaches to, and challenges involved in building resilience and undertaking activities to adapt to changing circumstances.

Therefore, the intent of this report is to provide a basis for the future stages of the CHAS process through the lens of resilience – a process that is intended to focus on institutional capacity building and coordination, community-led decision-making, long term adaptation and individual responsibility rather than heavy focus on hard infrastructure solutions. All of these aspirations are tenets put forth by the National Strategy for Disaster Resilience in framing nation-wide resilience and adaptation outcomes.

Relevantly, current projections for Queensland's coastline by 2100 indicate:

- A projected sea level rise of 0.8 m
- Tropical cyclones are projected to become less frequent but those tropical cyclones that do occur are expected to be more intense, and may track further south.

The likely impacts associated with these changes mean that rising sea levels combined with storm tides are likely to cause accelerated erosion and increased risk of inundation. For settlements and infrastructure this is likely to result in damage to and loss of dwellings and infrastructure with community-wide impact. For ecosystems, sea level rise may lead to loss of habitat, and salinisation of soils may cause changes to the distribution of plants and animals.

The impact of increasing coastal hazards will affect Queensland councils in the areas of:

- Litigation and legal liability
- Community expectations
- Land use planning and development assessments
- Asset and infrastructure planning and management

In response to this the QCoast2100 program was developed to provide councils in Queensland with assistance to advance coastal hazard adaptation planning. The Coastal Hazards Adaptation Program (QCoast2100) will support all Queensland local governments impacted by existing and future coastal hazards to advance adaptation planning. The Program will facilitate the development of high quality information enabling defensible, timely and effective local adaptation decision-making through access to tools, technical and expert support and grants for eligible councils. The Program is funded by the Department of Environment and Heritage Protection (EHP) for the next three years ($4 million/p.a.) and will be delivered by the Local Government Association of Queensland (LGAQ).

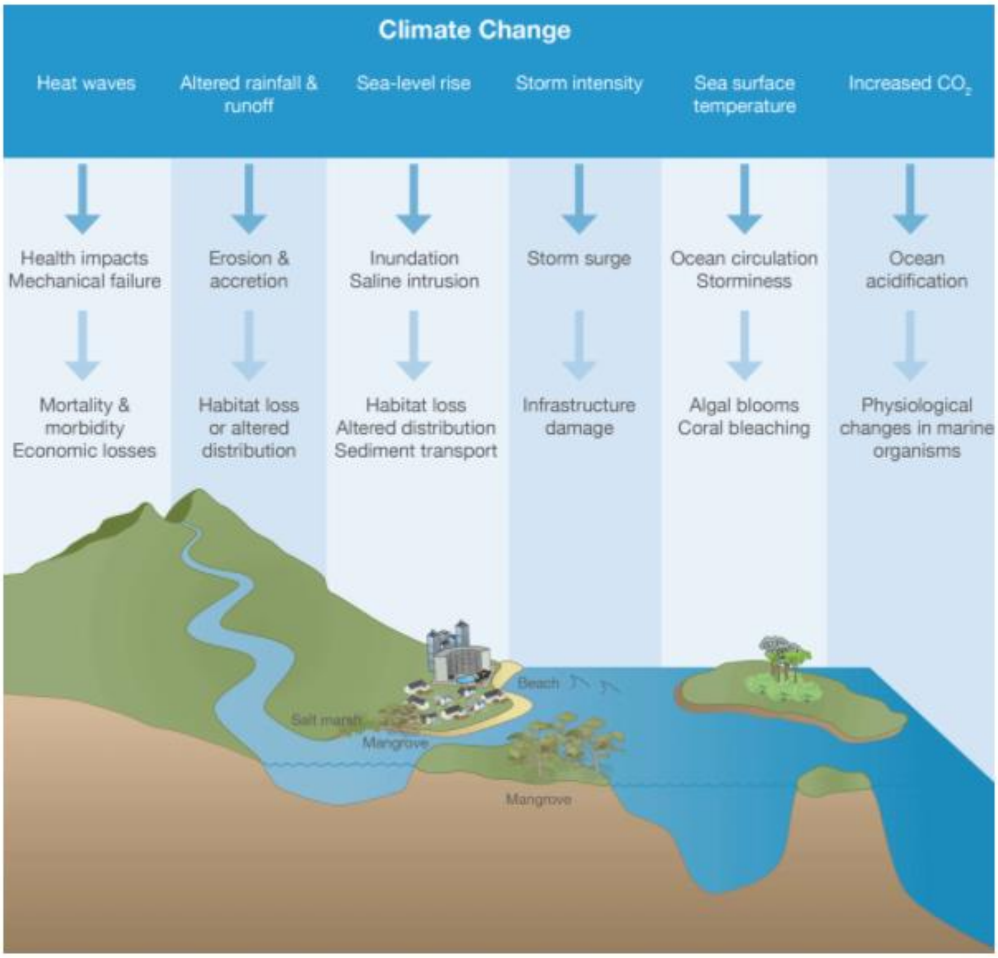

Figure 1-1 Likely Impacts in coastal areas (Source – Integration and Application Network, University of Maryland Center for Environmental Science)

It was recognised that coastal hazard adaptation planning will provide councils with the following benefits:

- Certainty for development and growth
- Identified cost effective actions to implement early
- Financial planning for high cost options
- Readiness to seek investment opportunities
- Demonstrated leadership to community
- Identified opportunities for innovation and renewal
- Opportunities for regional collaboration.

The coastal communities in the Bundaberg Region are likely to face challenges in the short and long term as a consequence of coastal hazards such as storm tide inundation and coastal erosion. Impacts from projected sea level rise and more intense storms due to a changing climate may increase the risks associated with these hazards and the risks may extend from areas currently at low or no risk.

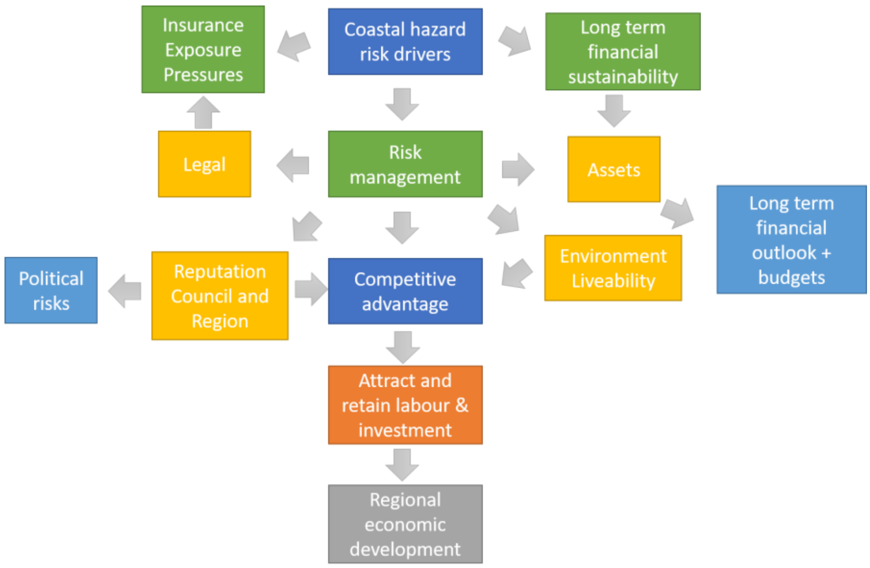

Figure 1-2 Key drivers for taking action on coastal hazard risks (Source – Buckley Vann, presented to LGAQ QCoast2100 Knowledge and Information Sharing Forum #2, May 2017)

1.2 Coastal Hazard Adaptation Strategy Process

The CHAS process has been developed to be undertaken through eight phases as described in the document '*Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments'* (MSGQLG).

Figure 1-3 describes the eight phases of the CHAS and it should be noted that that the development of the CHAS is undertaken as a cyclic process, whereby each phase is interconnected and can be revisited and refined as necessary.

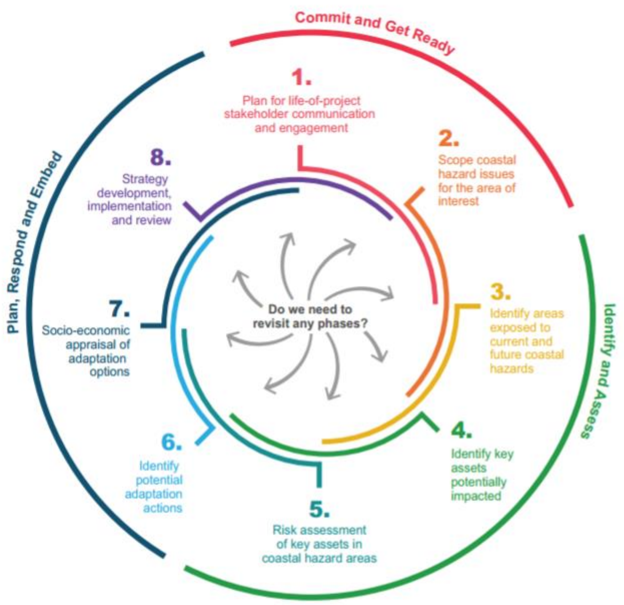

Figure 1-3 CHAS Project Phases

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Each of the phases can be categorised under three themes:

- Commit and get ready
  - Phase 1: Plan for life-of-project stakeholder communication and engagement
  - Phase 2: Scope coastal hazard issues for the area of interest
- Identify and assess
  - Phase 3: Identify areas exposed to current and future coastal hazards
  - Phase 4: Identify key assets potential impacted
  - Phase 5: Risk assessment of key assets in coastal hazard areas
- Plan, respond and embed
  - Phase 6: Identify potential adaptation options
  - Phase 7: Socio-economic appraisal of adaptation options
  - Phase 8: Strategy development, implementation and review

1.2.1 Key Objectives and Desired Outcomes

Broadly, it is intended the CHAS will be a plan to address coastal risks likely to be faced now and into the future. Key objectives include:

- Identifying coastal hazard areas;
- Understanding vulnerabilities and risks;
- Engaging with the community to understand their preferred approach to adaptation;
- Determining costs, priorities and timeframes; and
- Setting a forward program of implementation.

Guiding principles for preparing a CHAS include:

- Fit for purpose based on best available science, data and information;
- Adopts an adaptive management approach to allow flexibility over time;
- Considers locally specific objectives within regional context; and
- Stakeholder communication and engagement is critical for endorsement and implementation.

Desired outcomes for the CHAS, particularly from Council's perspective, include:

- Improved community ownership and awareness of the changing nature of the coastal environment – including both the 'attractor' and 'adverse' elements of living near the coast;
- Improved individual responsibility and therefore resilience in the face of changing environment, and in terms of improved understanding of risk that translates to improved individual decision-making;
- Improved governmental coordination and capacity to manage interactions with the changing coastal environment in a sustainable and strategic way over the long term; and
- Development of a clear adaptation pathway (or series of scenario-based pathways) for settlements, their urban systems, communities and government.

1.3 Driving the Bundaberg Region CHAS success through visioning

Council has already undertaken a process to identify determinants of success across a range of government functions (this is provided at Appendix A). This was supported by the Phase 2 workshop undertaken in May 2016, which expanded upon these concepts to encourage a discussion between the Council participants on what is actually sought to be achieved as part of the CHAS process, and what the 'end result' of the process looks like.

It is intended that, in order to guide the CHAS process over time, a vision is developed for the CHAS overall perhaps as part of Phase 3. A range of key themes relevant to the development of a CHAS vision were developed for the Phase 2 workshop and discussed in detail. These themes were then updated and improved upon at the workshop:

Figure 1-4 Themes for developing a vision for the CHAS

Further, it is also proposed that settlement-specific visions be developed (e.g. for Moore Park Beach, Bargara, Woodgate, etc) through community-driven development principles that articulate a 'future-state' for these communities that the CHAS should seek to achieve. This is considered to be a key part of the community engagement strategy moving forward.

1.4 Phase 2

The purpose of the Scoping Study is to identify the requirements, data, strategic and local scale issues and opportunities relevant to the region in order to set a solid foundation for subsequent phases of the Bundaberg Coastal Hazard Adaptation Strategy (CHAS).

The tasks include:

- Overview of the strategic issues and challenges
- Reviewing the technical data and reporting on any gaps and consequences
- Identifying vulnerable coastal assets
- Workshop to identify existing Council issues
- Socio and demographic review, to understand the potential risk profile of an area

- A review of zoned land to understand the quantum of land supply likely to be affected relevant information to inform the development of the CHAS
- Preparation of Scoping Study to provide the framework for future phases of the CHAS.

1.4.1 Council Workshop - Existing Council Asset Issues

Coastal hazard issues which currently (or are anticipated in the future) to affect Council and how it operates across various departments were captured during the Phase 2 workshop held in May 2017. The primary purpose of this workshop was to understand known coastal hazard issues, localities affected and the decision-making needs of each relevant Council department.

Representatives from a wide range of Council departments described a range of current and future issues which will need to be incorporated into Phases 3, 4 and 5 of the CHAS development to inform the overall strategy. The output has also been synthesised into the coastal asset identification in Section 4. Figure 1-5 presents the key output from the workshop across the Council departments. Furthermore, the workshop presented the opportunity for capacity building across Council in terms of its operating and service roles in the coastal area and how to start planning operations in known hazard areas.

Assets Strategic
Financial sustainability
LT management and MT sustainability
Difficult for Council to fund hard infrastructure
Focus on non asset solutions

Open Space and Parks
Managing community expectations on embellishments on foreshores
Resilient BBQ solutions in place

Land Use Planning
Disbelief over mapping
Concerns over property value and insurance
Individuals undertaking own works to mitigate risks
Limited development pressure in Moore Park and Woodgate, more in central coast area
Design responses to stormtide vs riverine flooding

Plumbing
LT high water tables
Groundwater mistaken for sewerage
Some local awareness
Groundwater monitoring/ warning system
Change the 3.6m design level?

Asset Management
BoM warning systems
Rehearsals/exercises
Access to critical infrastructure
Storage of works vehicles and items
Focus on quick recovery
Redundancy built in IT and comms – paper copies of information

Community Development
Need to turn negatives into positives
Council cannot fix everything
Intergenerational change – doing the right thing over time

Water
Water table issues
Need to quick resume services
More resilient design
Contingency planning

Environment / NRM
Impacts in liveability
Mangrove loss leads to flying fox displacement
Salt marsh change to mangrove, more midge
Migratory seabirds need mudflats
4WD access to beaches
Pedestrian access lost after storms
Erosion and marine debris affects turtles nesting and tourism issues
Fox control
Fish kills at Moore Park
Lagoon pollution at Bargara
Aquatic weeds and nutrients

Roads
Problem areas identified
Need refuge area with good connections
Road closed during intense rainfall events
Better drainage needed for low lying roads
Infiltration v groundwater surcharge

GIS
Data availability and speed of response
Storyboarding of services to simplify interpolation and understanding

Sewerage
Ground water
Smart solutions
Construction costs

Disaster Management
Psychology of resilient residents
Phone black spots exist
NBN / Internet operability

Media
Approaches need to be targeted and personalised

Asset Maintenance / Management
Ongoing costs and preplanning
Spares, maintenance etc

Figure 1-5 Workshop Feedback and Outcomes

2 STRATEGIC ISSUES IDENTIFICATION AND DISCUSSION

2.1 Introduction

The following section provides an overview of a range of strategic issues that are relevant in framing future work for the balance of the CHAS; and are intended as an important foundation for the successful implementation of practical adaptation and resilience improvements over time.

It is important that the CHAS focuses on societal resilience, community-owned and led decision-making, and institutional capacity and governance.

As a recognised leader in this field, our team has sought expert advice from Dr Gavin Smith, the Executive Director of the Center for the Study of Natural Hazards and Disasters (University of North Carolina Coastal Resilience Center) and the Department of Homeland Security's Center of Excellence – Coastal Hazards Center.

The strategic issues relevant to the Bundaberg context have been identified as:

1. Changing the understanding of hazards – data modelling and community awareness;
2. Institutional capacity and governmental coordination;
3. The need for scenario-based planning built on contingencies or changing circumstances;
4. Focus on funding and shifting from reconstruction to resilience;
5. Coordination of disciplines and governance across stakeholders; and
6. Community involvement in resilience and adaptation.

Several other issues (including the role of future development in influencing the achievement of adaptation and resilience outcomes – both positively and negatively) is also canvassed in this section.

2.2 Changing the understanding of hazards – data modelling and community awareness

2.2.1 Data modelling

Traditionally, methods used to assess and convey risk associated with natural hazards and disasters have relied on the concept of 'stationarity', which assumes we can rely on past records and data to project future risk. Over time and in a collective fashion, we have based our disaster risk reduction policies and programs on this understanding. For instance, current floodplain management policies generally assume taking actions to address the 1 per cent annual exceedance probability (AEP). Coastal hazard information currently also includes consideration of climate impacts such as sea level rise and increase in cyclonic intensity. This information is mapped and used to regulate development in our floodplains and coastal zones. Unfortunately, these maps represent a static depiction of risk rather than a series of maps that include future conditions.

In an era of climate change and increased uncertainty, there is a need to move beyond a strict reliance on a 'stationarity-based' approach, both in terms of developing improved models that account for this uncertainty while addressing additional issues of downscaling global climate data to a regional and ultimately local scale.

Ideally this data can inform federal, state, and local policies, programs, plans and the distribution of supporting resources. Proactive local governments and other locally-based organisations are often the best suited to address this issue when supported by external groups with data, funding and policies that are tied to a sound understanding of risk.

A community's awareness of hazards, including those that are subject to change based on a changing climate, require building close associations with networks in the emergency management community (i.e. those that have historically addressed natural hazards and disasters) as well as emergent groups focused on climate change adaptation (i.e. environmental groups, scientists, etc.).

The integrative theme in this effort can be the concept of resilience, to include the ability of communities to recognise natural hazard and risk, and take proactive measures to reduce the threat from both episodic and slow onset natural hazards and disasters.

Case Study - USA

For an example of a community that has adopted maps that convey future risk (due to the eventual build-out of their floodplains and the estimated changes in flood heights and lateral extent) see ***Charlotte, Meckleburg North Carolina's future conditions mapping effort***.
The maps are part of a larger holistic approach that includes their use to regulate new development in accordance with future conditions, the buy-out of flood-prone dwellings using largely local funding obtained through a local stormwater services fee. The city and county have subsequently transitioned these acquired lands into greenways and open space, thereby creating a public amenity while improving stream water quality (see Smith 2011, pp. 269-271).

2.2.2 Factors influencing community ability to modify policies and effective communication of risk

The ability to recognise and when possible, change the 'policy signals' we have developed to manage natural hazards and disasters remains an area requiring further focus. If we continue to rely on policies that rely on 'stationarity' as an organising principle, we will foster / encourage development, future investments, and risk perceptions among varied actors (i.e. federal, state and local government officials, businesses, insurance firms, developers, non-profits, individuals, etc.) that are either unaware of the changes in the underpinning elements of risk (i.e. frequency, intensity, duration, spatial extent) or incentivise poor choices.

Case Study - USA

In the US, two of the post powerful *disincentives* to enhance resilience include the ***National Flood Insurance Program (NFIP)*** and ***post-disaster assistance***.

- While the NFIP requires participating local governments to develop a Local Flood Damage Prevention Ordinance, which sets minimum standards for development in the floodplain, it also allows policy holders to obtain subsidized flood insurance rates that don't reflect actual flood risk. This has the effect of encouraging additional development in the floodplain. Efforts to alter this approach through the passage of new federal legislation was met by strong opposition among members of the US Congress whose constituents own property in flood-prone areas. The evolution of this federal policy bears monitoring over time.
- Post-disaster assistance, which is triggered by a federally-declared disaster, results in the disbursement of federal funds to assist local governments rebuild. Most of the funding is used to rebuild communities to their pre-event condition, thereby perpetuating risk and in some ways providing a powerful disincentive to proactively limit future development in know hazard areas.

A closely related challenge associated with both the NFIP and post-disaster assistance, is what the appropriate design standard in an era of climate change in fact is. Policy change that accounts for resilience in an era of climate change necessitates developing appropriate incentives and mandates that recognise that changes are occurring and design standards, land use zonings and public investments should account for these changes and associated uncertainties.

The ability to take action now, recognising changes are happening and are likely to grow worse over time, requires not only improved modelling and associated policies (informed by technical, administrative and fiscal capacity), it will take significant political will. For instance, this will prove particularly challenging for public investments in infrastructure (e.g. roads, levees) and public facilities (e.g. wastewater treatment plans, schools, hospitals) as the expected life of the structures may last for several decades when the effects of climate change are more likely to become evident. Yet decisions surrounding the investments in these structures and service infrastructure are taking place now and current-day decision makers should duly take resilience and adaptation into account for the long term. The costs of these investments will be evident in the short term while the benefits (i.e. reduced future climate change-related losses) may not accrue immediately.

2.3 Institutional capacity and governmental coordination

Given the challenges and complexities of both climate change adaptation, hazard risk reduction and disaster recovery, a governance-based approach is vital. One way to frame this challenge is through the use of Figure 2-1 to Figure 2-3. Whilst they address the specifics of disaster recovery, they can be used to frame governance-related actions that span hazard risk reduction as well as climate change adaptation.

An important lesson from the figures suggest that actions taken by any one stakeholder should be understood as taking place within larger disaster recovery assistance networks. The graphics represent a highly simplified, hypothetical version of reality. For instance, the node representing federal governments (see the upper left quadrant of Figure 2-1) is a distillation of many departments and agencies. These departments and agencies possess varied organisational cultures, but have been consolidated under one heading for the purposes of brevity.

The stakeholders noted below as nodes each provide or influence three types of resources which include funding, policies and technical assistance. The degree to which these resources address local needs can be highly varied. Also, the organisations denoted in the "zone of uncertainty" are often less engaged in pre-event planning for post-disaster recovery. Furthermore, it is less clear the roles they play after a disaster strikes.

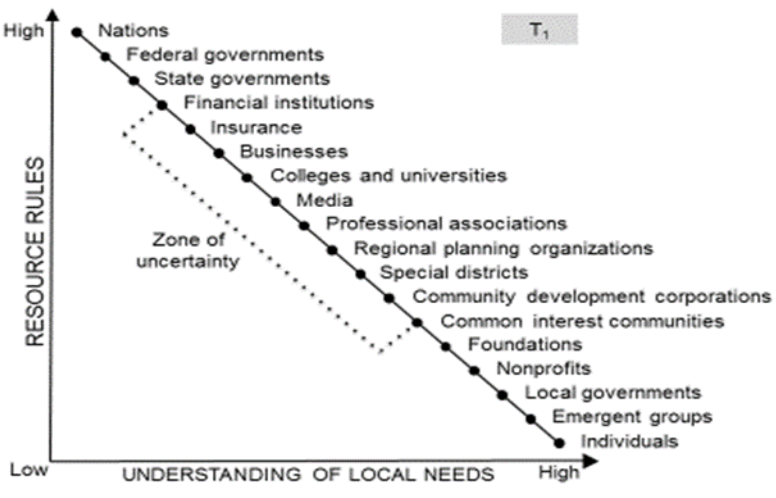

Figure 2-1 Hypothetical United States Disaster Recovery Assistance Network (Source: Smith, Martin and Wenger, 2017)

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Stakeholders often fail to think through how they can work together to coordinate the resources they each possess. Further compounding problems at the local level is that narrowly defined federal and or state post-disaster resources disproportionately drive the trajectory of recovery as local governments and others at the community level are often overwhelmed by the management of federal / state aid and have little time or capacity to coordinate assistance with others.

The failure to do so before a disaster through a robust, well-coordinated disaster recovery plan often leads to the duplication of resource distribution, or worse, the development of contradictory resource distribution strategies.

Case Study - USA

In coastal ***Mississippi following Hurricane Katrina***, well-intentioned non-profits rebuilt low-income housing (e.g. funding resource) to their pre-event condition (i.e. slab construction at grade) before local governments adopted higher construction codes and standards (e.g. policy resource) that better accounted for storm surge risk (based on newer, more accurate models) (e.g. technical assistance resource). The actions of non-profits also occurred before the federal government was able to provide funds to elevate new construction and homes slated for repair to this new, higher standard. Thus, the most socially vulnerable, which are often targeted by non-profits, were rebuilt in a way that perpetuates, rather than reduces social vulnerability.

The Mississippi example, which spans several resource providers (e.g. non-profits, local governments, federal governments) is indicative of another key recovery challenge; striking an appropriate balance between the speed of resource delivery with an adequate level of deliberation and planning needed to make more informed, coordinated, and ultimately collective choices that advance resilience.

Given the multitude of decisions and resource distribution permutations that are possible, it should not surprise us that recovery is extremely difficult to organise, particularly when communities have not developed robust, well-thought out pre-disaster recovery plans. Efforts to develop post-disaster recovery plans (common in the US) face major obstacles, including the creation of strong partnerships that advance collective action; and strong opposition to deliberative action versus a metric of success predicated on the speed of recovery and a return to normalcy.

In many cases, this push to return to normalcy may include returning to high levels of hazard risk, a poor economy, degraded environment, the lack of a planning culture and low levels of social capital. As more recent definitions of resilience suggest, following a permutation or shock (i.e. a disaster event), communities should strive to return to a new condition that represents an improved set of conditions than those that existed before.

The ability to change the rules governing resource distribution benefit from gaining a greater understanding of the varied programs, policies, and other decision-making processes that are in place and the degree to which they address local needs at the community and individual level. This requires pulling stakeholders together and having an honest, reciprocal dialogue about the projected needs facing a community in the pre- and post-disaster setting. This is reflected at Figure 2-2 (noted as T2). The process of ***policy learning*** across this larger, often loosely coupled, disaster recovery assistance network is driven, in part, by engaging in pre-event planning for post-disaster recovery that involves all members of the assistance network. Understood in the context of Figure 2-2, this means that all stakeholders have a high understanding of local needs.

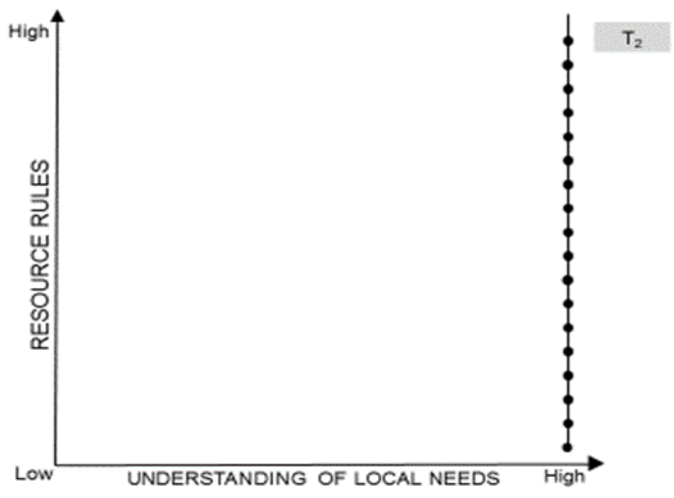

Figure 2-2 Disaster Recovery Assistance Network: Understanding Local Needs (Source: Smith, Martin and Wenger, 2017)

Continued, ***deep engagement*** and planning can lead to the eventual modification of policies that better meet local needs. It is not suggested that this is an easy task or a quick fix. Rather, it entails lengthy, often heated debate about varied resource distribution strategies and how they can be better coordinated. Given the complexities and potential conflict associated with resource distribution and management, it is highly advisable that communities develop and routinely update a pre-disaster recovery plan that allows for the time and collective action needed to address these issues.

Good recovery (and hazard mitigation) plans should address strategies intended to address policy issues germane to climate change adaptation (as per for example, non-stationarity, infrastructure investments, land use choices, future conditions mapping of floodplains, appropriate design standards, post-disaster assistance, etc. as described above. Research suggests that while response efforts may be guided by a sense of altruism, disaster recovery is often fraught with conflict over the distribution of scarce resources.

Change in bureaucratic institutions, non-profits, members of the private sector, and others with differing organisational cultures can be a major challenge. Trying to work through these issues in the aftermath of a disaster can be particularly difficult. In time series T3 at Figure 2-3 it is suggested that through good, long-term pre-disaster recovery planning, resource strategies are 'collectively optimised', which means that the rules influencing their application at the community level have been modified to better reflect local needs. The collective optimisation of resources can benefit by the development of strong federal and state disaster recovery plans that reflect an enhanced capacity to provide the appropriate types of resources to aid stricken communities both before, and after disasters.

Case Study - USA

In the US, national recovery policy remains largely focused on governmental solutions delivered after a disaster strikes. While the '***whole community***' concept has been touted by FEMA as a way to collaborate, it has yet to be clearly operationalised, even though the US Congress mandated FEMA to develop a national recovery strategy following Hurricane Katrina (***Post-Katrina Emergency Management Reform Act***). For more information on the problems associated with the US disaster recovery policy, see Chapters 9 and 10 in Smith (2011) and *Disaster Recovery in an Era of Climate Change: The Unrealized Promise of Institutional Resilience* (Smith, 2017) in *Handbook of Disaster Research*

Another important contextual reality in the post-disaster recovery environment is that varied stakeholders may take on leadership roles to address gaps in federal assistance. For example, after ***Hurricane Floyd (1999) in North Carolina*** the state government developed 22 state recovery programs to address gaps in federal assistance. These included funds to take on the ownership of the mapping of the state's floodplains (a traditional federal responsibility), the acquisition of lands in the floodplains and its transition to open space, and adding up to $70,000.00 in state dollars on top of federal funding used to purchase flood-prone housing. This was done to incentivise low-income homeowners to move out of flood-prone areas into lower risk housing on higher ground (Smith 2011, pp. 56-58)[1].

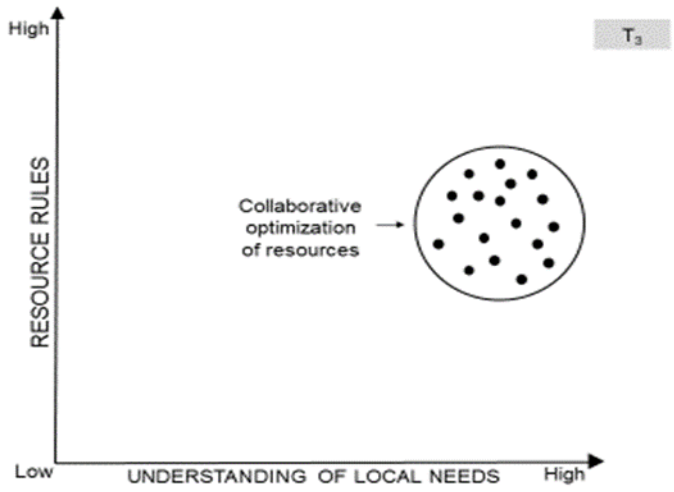

Figure 2-3 Disaster Recovery Assistance Network: Collaborative Optimisation of Resources (Source: Smith, Martin and Wenger, 2017) [2]

2.4 The need for scenario-based planning built on contingencies or changing circumstances

One way to address the issue of 'non-stationarity' is to adopt scenario-based planning strategies. This approach provides a means to address disaster recovery challenges in an era of climate change[3].

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[1] The relevance of the State of North Carolina's approach to Hurricane Floyd's disaster recovery to climate change adaptation can be found in Chapter 9 of Adapting to Climate Change: Lessons from Natural Hazards Planning (Glavovic and Smith, 2014). The chapter is titled Applying Hurricane Recovery Lessons in the United States to Climate Change Adaptation: Hurricanes Fran and Floyd in North Carolina, USA (Smith, pp. 193-229). Link is available in the Reference List at the end of this document.

For a distillation of the 264 recommendations drawn from the text that emphasize how natural hazards planning can inform climate change adaptation, see Chapter 16, Conclusions: Integrating Natural Hazards Risk Management and Climate Change Adaptation through Natural Hazards Planning, pp. 405-450 (Smith, 2014).

[2] A detailed description of these graphics and how they relate to disaster recovery can be found in Planning for Post-Disaster Recovery: A Review of the United States Disaster Assistance Framework (Smith, 2011). Their application as related to the concept of institutional resilience can be found in Disaster Recovery in an Era of Climate Change: The Unrealized Promise of Institutional Resilience (Smith, 2017).

[3] See Chapter 8 by Phillip Berke in *Adapting to Climate Change: Lessons from Natural Hazards Planning, pp. 171-190* (Glavovic and Smith, 2014).

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Scenario planning assumes the adoption of two broad types of policies, including robust and contingent strategies. Robust strategies include actions that are sometimes referred to as 'no-regrets' actions in that they may be adopted regardless of whether changes in risk occur. These may include the adoption of higher construction standards. Contingent strategies are created based on multiple scenarios and may be significantly different based on the scenario.

Case Study - USA

Following Hurricane Sandy, climate change adaptation measures were injected in the disaster recovery process, which is representative of how federal, state, and local governmental agencies as well as foundations modified the rules governing resource distribution. Examples include the use of Housing and Urban Development post-disaster funding to rebuild communities in a way that accounted for the uncertainties of sea level rise, and the hosting of the Rebuild by Design competition sponsored by HUD and the Rockefeller Foundation.

2.5 Focus on funding and shifting from reconstruction to resilience

The funding of disaster recovery assistance is largely focused on the post-disaster allocation of money. Very little in the way of resources, including funding, supportive policies and technical assistance to develop strong recovery assistance networks or engage in pre-event planning for post-disaster recovery, is provided to states or local governments. This results in an overemphasis on post-disaster resources that are narrowly defined, may not meet local needs, emphasise reconstruction activities and underemphasise building resilience over time.

Spotlight on Funding Arrangements - Australia

In 2015 the Productivity Commission completed its final report on the efficacy of current national natural disaster funding arrangements, taking into account the priority of effective natural disaster mitigation and the reduction in the impact of disasters on communities.

The inquiry concluded that Current government natural disaster funding arrangements are not efficient, equitable or sustainable. They are prone to cost shifting, ad hoc responses and short-term political opportunism. It also found that governments overinvest in post-disaster reconstruction and underinvest in mitigation that would limit the impact of natural disasters in the first place. As such, natural disaster costs have become a growing, unfunded liability for governments. The inquiry further identified that the funding arrangements impact the incentives to manage risks, including by using potent but politically challenging levers like land use planning. The reform imperative is greatest for states most exposed to natural disaster risk, like Queensland.

The inquiry report included a host of potential reforms, put forward for federal government consideration. A federal government position in response has not yet been announced.

The development of resilient communities, states, and nations benefit from a sincere commitment to a range of pre-event activities that represent a systemic rather than episodic approach. Resilience requires the adoption of proactive measures such as limiting development in known hazard areas, adopting more stringent codes that account for the uncertainties of climate change, and developing robust plans guided by the concept of governance.

There is also an important tie between disaster recovery and resilience in that the post-disaster environment may provide unique opportunities to enact change. These include a greater political will to act given the disaster has highlighted the direct effects of risk and vulnerability and major disasters often include a substantial infusion of post-disaster resources. This is an area in which Bundaberg Regional Council has direct experience, following the 2013 ex-TC Oswald flood event.

Being prepared to act in the post-disaster 'window of opportunity' to address goals like resilience can significantly benefit from sound pre-event planning. Among the most important actions include the development of strong coalitions that are willing and able to alter the rules governing the resources they manage to achieve goals like enhancing disaster resilience.

2.6 Coordination of disciplines and governance across stakeholders

Governance, described here in the context of the disaster recovery assistance network, requires an ongoing process of fostering coordination and the collaborative optimisation of resources held by a range of stakeholders. This approach requires investing the time needed to understand the organisational cultures of stakeholder groups as well as developing procedures that allow varied stakeholders to focus on the tasks they perform particularly well, as well as optimally using the resources they manage. On a related note, it is important to avoid duplication of resource distribution (thereby expanding the collective resource base) and limiting conflicting resource distribution strategies.

Given each stakeholder possesses a unique set of resources and coordinating how and when (e.g. pre- and post-disaster, appropriately timed in the aftermath of a disaster across stakeholders – see the Mississippi example following Hurricane Katrina) they are disbursed is important.

Understood in the context of professions, another area that hinders recovery and resilience efforts is the limited level of coordination between local emergency managers and land use planners. For instance, in a six-year study[4] of hazard mitigation plans developed in US communities, most were led by an emergency manager. In these instances, the plans placed limited emphasis on land use planning measures as a proactive way to reduce hazard risk. Those plans that were led by a land use planner placed greater emphasis on land use measures as a risk reduction strategy.

2.6.1 Aligning governance processes

In the local Queensland context, coordination across governance operations is considered critical to the successful preparation and implementation of a CHAS – it is essential to understand core governance functions and operations and how coastal hazard adaptation might influence and integrate with these this. This can be internal to a local government (across the various internal departments), and between local and state levels of government.

In the local government context, adaptation actions will need to be embedded across a range of core governance functions in Council, including:

- long term financial planning and annual budgets
- asset management and planning
- disaster management and planning
- corporate and operational planning
- land use and infrastructure planning
- organisational development and workforce planning
- community and stakeholder engagement policy and plans.

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[4] For more information on the study's research findings, see the website *Beyond the Basics: Best Practices in Local Hazard Mitigation Planning* at http://mitigationguide.org/research/

For example, in the event of a natural disaster for which adaptation action is required at short notice and/or relief funding becomes available, the CHAS can provide direction on what actions should be undertaken and where funding should be targeted. Actions undertaken by council, other agencies and stakeholders should be consistent with the direction and outcomes intended by the CHAS avoiding the potential for ad-hoc decisions that may result in maladaptation or prevent actions that may be sensibly required in the future.

By involving a wide range of Council functions from the outset, the work in Phase 8 which brings together the strategy development, implementation and review with any internal organisational change management plan designed to provide a structured and systematic way to guide the implementation of the CHAS can be facilitated.

Key Council policies, strategies and plans that interface with and should be aligned to the CHAS outcomes include:

- Council budgetary processes
- Corporate Plan 2017-2021
- BRC Community Plan 2031
- Long Term Financial Plan 2012-2022: Towards 2031
- Operational Plan
- Bundaberg Region Planning Scheme
- Local Government Infrastructure Plan (part of Bundaberg Region Planning Scheme)
- Bundaberg 'Open for Development' initiative
- Bundaberg Region 'A Better Climate for Business' 10 Year Blueprint for Sustainable Economic Growth
- Human – Social Recovery Group activities
- Natural Resource Management, Natural Areas and Land Protection activities & policies
- Local and Sub-ordinate Laws, such as:
  - Community and Environmental Management
  - Local Government Controlled Areas Facilities and Roads
- Council Policies, such as:
  - Organisational services
    - e.g. Integrated Risk Management Policy
    - Investment Policy
  - Infrastructure and Planning Services
    - e.g. GP-3-114 Design and Construction Standards for Sewerage Network Infrastructure, GP-3-113 Water Supply Design and Construction Standards for Network Infrastructure

2.6.2 Aligning with statutory processes

A wide range of other statutory processes or requirements the local government is responsible for implementing (including land use planning instruments, corporate planning, long term asset planning and the like) are likely to have a programmatic interface with the CHAS process.

While naturally the CHAS process is time-bound (largely due to funding parameters), other statutory processes that may relate to or directly interface with the CHAS may also be independently timebound or have specific technical requirements of which the CHAS should be cognisant.

This issue is described in the National Land Use Planning Guidelines for Disaster Resilient Communities, which notes:

In many instances, a natural hazard management process may occur quite independently of a plan preparation process, even in the one organisation, and the involvement of planners or other built environment professionals can be overlooked. Further, the time required to undertake both processes (both are routinely multi-year exercises) leaves little opportunity to align these processes so that the natural hazard process can inform the planning one.

Equally, the planning process needs to be cognisant of not just one but often multiple natural hazard processes that may occur at different times and budgeting and capacity constraints allow. Rarely then is there the opportunity for a natural hazard process to fully align with the plan preparation process – when it does, the opportunity exists for true integration of land use planning and natural hazard management.

A range of capability, capacity, financial and timebound issues can preclude the achievement of this theoretical ideal. However, practical advice on how to overcome this reality of multiple processes running at differing times, and how planners can maintain integrity in their own processes even though they may not have the full benefit of up to date outputs from the relevant natural hazard management process is required.

An example is the upcoming adoption of the *Planning Act 2016* which will have a range of implications for Council in terms of its planning scheme. Further, the recent release of the new *State Planning Policy* may have significant implications for the approaches taken to addressing coastal hazards as they relate to future development.

2.7 Community involvement in resilience and adaptation

Deep and sustained community involvement in pre- and post-disaster decision making and planning is vitally important. This engagement, if done correctly, should have the effect of describing unique local needs, and based on this assessment, developing targeted strategies to address them. Community involvement should also involve empowering communities to inform and ultimately influence how the rules governing resources provided by stakeholders across the larger disaster recovery assistance network are defined and altered. The use of indigenous knowledge, while vitally important, is often ignored when crafting policy delivered by external organisations.

Potential stakeholders that can assist in linking external assistance with local needs include state governments, as they are often the translators of federal recovery policies to local governments. In order to be effective local advocates, states should engage in assisting communities develop pre-disaster recovery plans that highlight issues and unique local needs.

Other stakeholders that may serve as local advocates include professional associations whose memberships are often populated with local officials (e.g. planners, building officials, public works officials, etc.). Other local advocates may include non-profits and community organisations.

Assistance networks are substantially more effective if they span both the horizontal (e.g. local actors like local governments, community organizations, local business owners, etc.) and vertical (local, state, regional, federal, and international governments) dimensions. This concept is often referred to as horizontal and vertical integration.

In order to capture the collective knowledge, influence, and power of these organisations at the local level, typically requires a local community champion. Past research suggests these champions may possess varied characteristics, such as the technical experts, charismatic leadership and power.

Case Study - USA

In ***Tulsa, Oklahoma***, the City relied on a local champion who was successful in drawing attention to repetitive flood loss. For more information on this case, see Smith (2011, pp. 146-149).

2.8 Potential future development

2.8.1 Zoning for future development

Spatial controls set limits on the type and extent of development that can happen in particular areas. These controls may take the form of prescriptive zones, overlays with associated controls or reference to resource documents.

Zoning approaches can be utilised to specify particular development intents for certain areas and are linked to built form outcomes such as density and type of use. Particular types of zones such as rural, environmental management, open space and agricultural zones are routinely employed to limit development or certain types of uses occurring in areas strategically identified as inappropriate to accommodate urban development. Zoning tools can therefore provide an essential opportunity to regulate development and the nature of community growth where exposure to climate-related risk is identified5.

It is necessary to identify appropriate land uses first, addressing built form thereafter. Should the proposed land use be deemed as strategically compatible with the risk, it should be zoned accordingly to provide clarity for the community. It is critical to strive for certainty in development intent. Policy ambiguity creates confusion and unintended outcomes in implementation and in some cases, defers important hazard considerations to the development assessment stage where competing planning interests can present difficulties for assessment managers.

Built form considerations can address risk only to the extent that you can seek to limit density or types of development from occurring in a manner that is inconsistent with the intent of the zone. This approach seeks to set a certain level of community expectation with regard to how specific land parcels and localities may be used into the future.

Zoning changes can be undertaken for land parcels and localities where climate hazard has been identified at a level which does not correspond to the nature or density of development permitted by current zoning controls. This action is often referred to as 'back-zoning' and is typically used in instances where natural hazard management plans, climate studies, strategic settlement planning or specific risk assessments are completed after plan preparation, to retrospectively amend planning instruments to align with the outcomes of those studies where deemed appropriate by the relevant jurisdiction. Another method is to introduce 'precinct' or 'sub-area' provisions where existing development has occurred, but where strategic settlement planning identifies a conflict and further development or increased density should be limited.

[5] National Land Use Planning Guideline for Disaster Resilient Communities (MWH; Planning Institute of Australia; Attorney-General's Department, 2016)

2.8.1.1 Emerging communities, local development areas and urban growth areas

A portion of land within the Emerging communities zone within the Bundaberg region is mapped as potentially erosion prone or subject to potential storm tide inundation, as well as areas within designated local development areas and urban growth areas. Whilst overlay approaches can articulate risk tolerances and enhance resilience outcomes through the adoption of specified parameters for acceptable development, zoning approaches may represent a clearer, more effective outcome in those instances where design or siting measures (as provided by overlays) are unable to effectively overcome the risk profile of the locality.

2.8.2 Developer-led proposals

Separate from consideration of land use zoning is the concept of developer-led proposals which remains a relevant matter given the performance-based approach of the current land use planning system in Queensland. Under this system and having regard to the *Planning Act 2016* (the Act), despite the strategic allocation of land use zones through the planning scheme, the ability to 'vary' or 'override' zoning on an ad hoc, site-specific basis is permitted under the legislation.

Typically, developer-led 'variation' applications are sought to overcome issues relating to 'unforeseen' activities or out-of-sequence development however, such applications can be utilised in a variety of contexts depending upon relevant planning grounds. Whilst these instances are difficult to foresee, there may be opportunities to limit such instances in locations either requiring further investigation as well as those which may be identified as potentially at risk of climate-related impact.

The Act allows for the identification of 'prohibited development' within a planning scheme, to prescribe those types of development which the community and / or local government does not wish to see in specific location, contexts or instances. This could supplement the approach of the Limited development zone by identifying specific uses or locations outside of this zone where development will not be contemplated by Council. This of course, may not exclude all developer-led, unforeseen or out-of-sequence proposals which may arise and which could be considered by Council but it does offer an additional tool to supplement other development controls in a flexible use-oriented and / or spatially-specific arrangement. Aside from prohibited development controls, there remain a number of opportunities to potentially foreshadow (to that degree possible) land uses on a likelihood / consequence spectrum to identify potential impacts and the need for any interventionist action within the planning scheme, or other relevant classifying instruments.

2.8.3 Council investment strategies

Similar to the zoning of land for future urban use, other common practices and activities within existing urban environments may, over time, require significant consideration by local government with regard to longevity of potential works. Over time, the need for strategic approaches to boost economic vitality within specific localities may be considered where various drivers exist (population growth, industry expansion, etc.), placing pressure on the services of existing localities and in particular, town centres. Such strategies typically underpin local government economic investment sought to stimulate private investment.

Other instances of Council-led investment relate to repetitive repair/replacement of infrastructure (including roads, water, sewerage, and drainage) damaged or decayed as a result of hazard or climate induced circumstances such as via direct impact or rising water tables. The decision to continue to promote settlement in an area particularly susceptible to hazard or climate-related impacts can have significant ongoing expense for Council which may be disproportional to other areas not so affected.

In locations identified as potentially erosion prone or subject to storm tide inundation, the scale of continued investment into the future therefor represents a factor for consideration. Such instances of continued investment, or incentivised development (i.e. infrastructure charging incentive areas), in areas susceptible to either episodic or insidious climate-related impacts could, in the longer term, prove to be impractical from a cost / benefit perspective where the design life or use of such investment is potentially curtailed.

It may be the case that other drivers, aside from climate-related impacts, provide the initial impetus for local government to investigate the opportunities and challenges involved in instances where strategic investment strategies, such as town centre or main street revitalisation projects, are identified. However, climate and hazard related factors remain a critical consideration in such decision-making.

3 EXISTING TECHNICAL INFORMATION AND DATA

3.1 Introduction

To assist in setting a solid foundation and framework for the future phases of the CHAS, this study has collated existing technical information and data from Council and external sources. The following sections describe and analyse the information gathered. A gap analysis has been undertaken and ta knowledge gap rating along with relevance and consequence has been assigned to assist in the determination whether further investigations are required to meet the requirements to develop the CHAS.

3.2 Available Reports

The following reports in Table 3-1 were obtained from Council and external sources and were reviewed as part of Phase 2.

Table 3-1 Available Reports

Title	Summary	Relevance
State-wide Natural Hazard Risk Assessment Project Summary - Risk Frontiers, 2011	A state-wide summary of natural hazard risks. Bundaberg was identified as high exposure to risks related to tropical cyclones	This is not a location specific assessment.
Climate Change: Implications and Liability from Sea-Level-Rise and Storm Surge on the Burnett Mary Regional Coastline - University of Sunshine Coast, 2009	A preliminary level scoping study to identify potentially vulnerable communities and locations along the coast from Agnes Waters to Inskip Point. The study does not include Bundaberg itself.	The report identifies the need for better flood related information in specific locations but did not undertake these assessments. It does include a risk register for all hazards.
Disaster event: Bundaberg Region's record flood, tornados and storm surge – Bundaberg Regional Council	Discussion paper describing the events surrounding Ex TC Oswald in January 2013.	Description of impact of disaster on systems and the social impacts they caused.
Hazard Evaluation Report Flood - Bundaberg Regional Council, 2017	The aim of the report was to confirm the extent of flooding across the whole local government area and identify those areas for further investigation. The report includes both riverine and coastal flooding and brings together flood information from a range of studies and sources across the LGA. It does identify those Urban or Growth areas impacted by flood hazards. No new studies were undertaken.	Provides a comprehensive review of available flood related hazards within the region. The focus is on the 1% AEP event for on land-use planning. A useful reference for future stages for identifying relevant studies and available models. Each flood study for a local coastal creek or river system will need to be reviewed to determine if joint riverine and coastal inundation was considered.

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Title	Summary	Relevance
Bundaberg Coastal Storm Tide Study – BMT WBM 2013	A detailed technical assessment of cyclonic storm tide inundation for the Bundaberg region. The study involved development of a detailed numerical modelling system to simulate tropical cyclone generated storm surge events. Storm tide estimates provided for events from 5% AEP to 0.01% AEP for existing mean sea level and for a climate change scenario assuming +0.8m sea level rise and a 10% increase in maximum cyclone intensity. Coincident riverine flooding in the Bundaberg River was analysed but does not appear to have been included in developing the final design storm tide estimates.	Provides the most update to date information for local scale coastal inundation hazard and adaptation assessments. The work meets many of the requirements of the minimum standards regarding coastal inundation.
NDRP Storm Tide Hazard Interpolation Study – GHD 2014	A state-wide study to provide storm tide hazard information across Queensland. Data from previous studies was applied using a normalisation approach to estimate storm tide levels for 5% to 0.01% AEP events across the state. Modelling was only use to estimate of the Theoretical Maximum Storm Tide. Climate change was not considered.	As noted below, the Griffith (2016) report recommends the use of the 2013 storm tide estimates for the Bundaberg Region rather than the outputs of this study.
Bundaberg Storm Tide Adaptation Project Review of Storm Tide Inundation Studies – Griffith University 2016	The report is a technical review of the BMT WBM (2013) and GHD (2014) analyses to address an issue with conflicting storm tide heights at two residential Bundaberg sites.	The review concludes that the storm tide levels reported in the NDRP study (see above) are likely to be unreliable. The overall conclusion is that the BMT WBM report provides more accurate estimation of storm tide levels at Bundaberg based on current practice.
Elliott Heads Study - Griffith Centre for Coastal Management, 2010	A scoping study to assist with entrance management considerations at the Elliott River entrance. The study involved field data collection (entrance bathymetry, water levels, tidal currents) and numerical modelling of existing conditions along with possible entrance management options.	Field data and modelling outcomes may be useful should numerical modelling of erosion processes at Elliot Heads be required in future stages of the CHAS.

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Title	Summary	Relevance
Coastal Observation Programme – Engineering (COPE) Bargara – Woongarra Shire for the years 1976 – 1984 - Queensland Beach Protection Authority, 1985	Provides a summary of analyses undertaken by the Beach Protection Authority on wind, wave and beach processes data at Bargara Beach. Data was collected by volunteer observers under the COPE program for the eight-year period of June 1976 to June 1984.	Data relates to Bargara Beach and includes winds, waves, longshore currents and beach levels/profiles. Data could be used when verifying numerical modelling. The COPE program also included observations at Woodgate (not reviewed, but expected to be of similar technical content).
Hervey Bay Beaches – a detailed study of coastline behaviour along the mainland beaches of Hervey Bay, South-east, Queensland, Australia - Queensland Beach Protection Authority, 1989	Presents the findings of a comprehensive regional study of coastal processes affecting local beaches; and offers comprehensive management plans for the various coastal reaches within the area.	The study area extends from Urangan in the south, to the Kolan River in the north. It therefore does not include the coastline in the northern part of the Bundaberg LGA, from the Kolan River to Baffle Creek.
	Shoreline Erosion Erosion prone area widths (EPAW) are calculated for 56 adjoining coastal reaches along the approximately 70km of coastline between the Burrum River and the Kolan River.	The EPAW is calculated in accordance with current 2017 practice of considering the combined effects of long-term shoreline change; storm erosion due to a 1% AEP event;, sea level rise and an allowance for dune scarp collapse. The sea level rise used for the calculations is not stated. Long-term erosion trends are determined from historical records up to 1988. Characteristics of the 1% AEP event used to calculate storm erosion are based on: • short-term wave records and now outdated numerical modelling of wave hindcasting and wave transformation processes. • associated storm tide level is higher than more recent studies have identified as a 1% AEP event.

Title	Summary	Relevance
	Storm Tide Inundation (Section 7.4) A numerical modelling study was undertaken to establish extreme coastal water levels for 14 locations along the coastline from Gladstone to Inskip Point. The report also provides wave setup and run-up estimates along the same coastline. No sea level rise simulations were included	The storm tide estimates along the coastline between Baffle Creek and Burrum Heads (Table 7.7) can be compared directly to those in Table 4-3 of the (2013) storm tide study. For all locations, the storm tide estimates in this study exceed the (2013) values by between 0.4 to 0.7m for the 1% AEP event. This has implications for the cyclone related erosion calculated as part of the erosion prone area width determination. The adopted storm tide levels used for the calculations (detailed in Table 11.4) corresponds to approximately the 1% AEP values from this study.
Bundaberg Area Erosion Prone Plan – Queensland Government 2015	Provides the extent of foreshore areas within the Bundaberg LGA designated as prone to erosion in the year 2100 as a consequence of a 1% AEP event. Includes the effects of a 0.8m sea level rise and a 10% increase in maximum cyclone intensity	Erosion prone area widths (EPAW) are based on the findings of the 1989 study Hervey Bay Beaches by the Beach Protection Authority (see above), but are amended to include the effects of 0.8m sea level rise. The contribution to the designated EPAW by long-term shoreline changes, and storm erosion due to 1% AEP event are those determined by the earlier 1989 study.
McCoys Creek Flood Stud – GHD 2013	A catchment flood study of McCoys Creek catchment and floodplain to simulate the 2% AEP, 1% AEP, 1% AEP + 2100 climate change (20% increase in rainfall intensity), 0.5% AEP and 0.2% AEP design flood events. Sensitivity tests for high Burnett River levels.	Not critical for coastal adaptation studies although the modelled inundation results should be reviewed taking into account sea level conditions to 2100 and the impact this may have on water levels in the Burnett River.
Burrum, Cherwell, Isis, Gregory River Flood Study – GHD 2015	A catchment flood study of the Burrum River and major associated tributaries (including Gregory River, Isis River, Cherwell River and Stockyard and Peep Creeks) simulated the 2%, 1%, 0.5%, 0.2% AEP and PMF design flood events. For all design events, a mean high water spring (MHWS) tidal level of 1.23m AHD was adopted as the tailwater condition. Did do sensitivity tests with a 1% AEP sea level rise tailwater (2.88 m AHD).	The sea level rise scenarios indicate significant additional inundation of coastal communities at Burrum Heads and this should be considered within coastal adaptation planning.

3.3 Available Data

A range of GIS asset and spatial data was provided by Council for the Scoping Study. Supplementary data was also obtained from external sources to assist in the identification of assets within the study area. This data has been used to create a Bundaberg Region CHAS mapping portal where existing relevant data sets of coastal assets can be viewed. This tool is discussed in more detail in Section 4.3. During the process of creating the mapping portal it became apparent that some of Council's existing data sets require more detailed review to ensure that they were up to date and did not hold duplicate data. Where possible, this has been undertaken, however, it is likely that there are additional data sets that would be important to include when undertaking Phase 4 of the CHAS.

3.4 Technical Knowledge Gaps & Recommendations

Based on the collation and review of available reports, a gap analysis has been used to identify gaps and their significance for this and future coastal hazard assessments examining the two technical knowledge areas of:

- Storm tide inundation
- Shoreline erosion[6]

Ranking of the significance of the data or knowledge gap recognises that the absence or incompleteness of different types and sources of information may have varying impacts. A significant gap could limit the ability to proceed with a detailed assessment within the study area. The first pass storm tide project scoring criteria as described in Annex IV of the MSGQLG is included in Appendix B.

A description of the qualitative scale adopted to rate the relative importance and consequence of identified gaps on the ability to proceed and/or objectives of the detailed coastal climate change assessment has been presented in Table 3-2. The knowledge gap analysis is presented in Table 3-3.

Table 3-2 Summary of Gap Rating Scale

Knowledge Gap Rating	Description of Relative Importance	Consequence
None	No Knowledge Gap has been identified. Adequate information is considered available to assist with a detailed coastal climate change study assessment.	No additional information or data required
Low	While a knowledge gap has been identified, it is considered to be of limited consequence to the overall study objectives and/or the gap can be overcome by routine analysis or minimal additional collection efforts.	The detailed assessment can proceed, but additional data/information may need to be developed during the assessment.
Medium	A significant gap has been identified that is likely to have some bearing on the robustness of the analysis that can be undertaken and the ability to achieve the study objectives and/or the knowledge gap can be overcome but only with substantive additional analysis or data collection efforts.	An assessment of the ability to fill the knowledge gap and the value of the knowledge to the detailed assessment would need to be considered before proceeding with a detailed assessment.
High	A major gap has been identified that will significantly limit the robustness of the analysis that can be undertaken and significantly compromise the ability to achieve the study objectives and/or the knowledge gap can be overcome only by extensive additional analysis or data collection efforts.	The detailed assessment cannot proceed until this knowledge gap has been completed

6 Coastal erosion includes the permanent inundation of land by tidal water from sea level rise.

Table 3-3 Technical Knowledge Gap Analysis

Knowledge Area	Gap Identified	Relative Importance / Consequences	Scope Required to Fill Gap	Overall Knowledge Gap Rating
Storm Tide Inundation	Not stated if Bureau of Meteorology advice obtained	Minor	Confirm with study authors	**Low**
	Synoptic scale interactions considered	Minor	Confirm with study authors	**Low**
	Inter-annual or inter-decadal variabilities not discussed	Minor	Further analysis could be included to characterise these variabilities	**Low**
	Overland decay or land interactions not considered	Minor	Investigate the potential implications of this on the study outputs. Unlikely to require further simulations	**Low**
	Detailed analysis of terrain data accuracy both for modelling and mapping purposes. An issue with the LiDAR dataset used for the storm tide study (BMT WBM, 2013) is alluded to in the report but no details are provided. It is also noted in the study limitations that the "risks to the community from inundation and wave action are limited by the resolution of the DEM in the near shore areas".	Mapped flood extents and depths may not accurately reflect topographic variability and therefore over or underestimate coastal inundation in some areas.	A comprehensive review of the terrain model used for the storm tide study (BMT WBM, 2013) is required. The model resolution appears coarse across floodplain areas and may not have accurately resolved local features would could affect flood behaviour. The predicted storm tide level data should be remapped using a high-resolution terrain model (say 1m grid) to improve the mapped inundation extents and depths.	**Medium**

Knowledge Area	Gap Identified	Relative Importance / Consequences	Scope Required to Fill Gap	Overall Knowledge Gap Rating
	Model resolution across urban areas does not meet minimum standards (<10m).	The BMT WBM (2013) storm tide study does not clearly describe the model resolution, however it appears to be greater than the minimum grid/mesh size 10m specified in the minimum standards. As the model has not been used to dynamically assess and map the design flood events the mesh resolution has no impact on the overall storm tide levels or maps.	Local scale models developed to dynamically assess storm tide inundation for coastal communities at a fine scale,	**Medium**
	Coincidence of coastal and fluvial flooding. As noted in the Griffith University (2016) review, the storm tide study did undertake a joint probability assessment for the Burnett River but this does not appear to be considered in the parametric model used to determine AEP water levels. Various other flood studies have been undertaken for creeks and rivers within the region but none of them address the coincidence of coastal and fluvial flooding. Most have applied conservative downstream boundary conditions.	The available information indicates that flooding on the Burnett River around Bundaberg is dominated by riverine events rather than storm tides, however this may vary closer to the coast and a combination of riverine and storm tide flooding may produce elevated water levels. Several the other flood studies for creeks and rivers within the region do mention the susceptibility of the downstream reaches to coastal water levels but the impact is not quantified.	The 2017 Hazard Evaluation Report by BRC provides a reference for riverine studies and notes where they have considered climate change. A more detailed summary of the modelled flood scenarios including climate change is required to confirm if/where any knowledge gaps existing. This review should also include consideration of where data for a range of AEP events is available and any consideration of climate change (specifically sea level rise increments). For the available flood studies the impact of coastal water levels on flooding should be quantified. This could be done as a mapping exercise or where significant infrastructure is affected a joint probability assessment would be appropriate.	**Medium**

Knowledge Area	Gap Identified	Relative Importance / Consequences	Scope Required to Fill Gap	Overall Knowledge Gap Rating
	The inundation mapping methodology detailed in the (2013) storm tide study is not clearly described and includes wave setup/run-up allowance in areas along the coast. The mapping uses a static 'bath-tub' approach rather than dynamic modelling of the inundation.	It is noted in the (2013) study that some locations not directly hydraulically connected may be included and that the storm tide volume is not considered. This may overestimate the likely inundation extents.	Remap the available peak storm tide levels across the area using a more detailed (min of 1m grid) terrain model. Include filtering for hydraulically disconnected areas. Remove wave setup/run-up allowance from the mapped peak water level and apply site specific estimates as freeboard allowances as per minimum standards.	**Low**
	Sea level rise increments used are conflicting in different studies; do not meet current predictions; or do not cover a range of values. Storm tide peak water level estimates are available for only existing mean sea level and assuming +0.8m sea level rise. Flood studies for coastal creeks and rivers only include +0.8m scenarios as sensitivity tests.	The availability of a single climate change scenario, specifically only one sea level rise increment, limits the ability to assess potential trigger levels or thresholds for adaptation responses. This applies to both technical as well as economic assessments.	Expand available analysis to include a range of sea level rise increments up to and beyond +0.8m. This applies to the flood studies for all rivers and creeks along the coastal line as well as for the storm tide. Potentially a simplified analysis could be developed to address this gap to limit the need for additional modelling.	**High**

Knowledge Area	Gap Identified	Relative Importance / Consequences	Scope Required to Fill Gap	Overall Knowledge Gap Rating
Shoreline Erosion	The extent of potential shoreline erosion has not been determined for a range of future climate change scenarios. Only a 0.8 metre sea level rise (predicted for year 2100) has been considered in EHP determination / mapping of Erosion Prone Areas.	The availability of a single climate change scenario, specifically only one sea level rise increment, limits the ability to assess potential trigger levels or thresholds for adaptation responses. This applies to both technical as well as economic assessments.	Expand available analysis to include a range of sea level rise increments up to and beyond the +0.8metre scenario.	**High**
	The extent of potential shoreline erosion has not been determined for a range of Average Recurrence Intervals. Only the implication of a 100 year ARI event has been determined.	As noted in the *Learnings Report – Coastal Hazard Adaptation Strategy for Townsville (Pilot Project)*, the CHAS must consider a full range of ARI events and the relationship between the vulnerability and the hazard level (i.e. the topographic distribution of assets).	Expand available analysis to include a range of storm events (more frequent and rarer) than the nominal 100 year ARI.	**High**

Knowledge Area	Gap Identified	Relative Importance / Consequences	Scope Required to Fill Gap	Overall Knowledge Gap Rating
	Whilst the methodology used to calculate the width of the erosion prone areas is that currently required by, the data and technical assessments underpinning those calculations are nonetheless some 30 years old. They are based on the outcomes of the Beach Protection Authority's 1989 *Hervey Bay Beaches* Study.	Predictions of the extent of shoreline recession may not be accurate.	Expand available analysis to include more recent data and contemporary calculation/modelling techniques.	**Medium**
	The extent of potential shoreline erosion along the riverbanks, protected waterways and estuaries has not always considered site specific topography or nearshore bathymetry, nor determined by generic geomorphic/exposure considerations - but instead rely on default 40 m values.	Extent of shoreline recession in response to severe storm events not accurate – can either under- or over-predict storm bite at any particular location.	Expand available analysis in areas of having significant environmental, social, economic or cultural values to include site specific topography/bathymetry in erosion considerations.	**Medium**
Marine infrastructure	The current physical condition of existing foreshore protection infrastructure (groynes, seawalls, breakwaters, entrance training walls) is not well documented.	The future performance and effectiveness of foreshore protection measures may not be robust enough to accommodate future conditions.	Undertake structural audit of existing foreshore protection works to determine both existing and future effectiveness – and ascertain any need for future structural upgrading or remediation.	**Medium**

4 PRELIMINARY COASTAL ASSET IDENTIFICATION

4.1 Introduction

To define the susceptibility of the coast and both tangible and intangible assets to coastal hazard including inundation and erosion it is important to identify the different forms these hazards may take and therefore how they may impact.

The tangible and intangible assets in the Bundaberg Region have been categorised as either:

- Environmental
- Social
- Economic
- Utilities
- Marine infrastructure

Using the GIS data sets provided by Council and those obtained from external sources, assets have been identified which lie within the Coastal Management District (CMD). The CMD area considers the declared erosion prone area mapping which includes a projected sea level rise of 0.8m to 2100 from climate change. The CMD mapping generally includes lots where permanent inundation by tidal water are included.

4.2 Potential coastal hazard impacts

An understanding of dynamic coastal processes, their interactions, and the factors that lead to inundation and erosion (as shown in Figure 4-1) is critical for successful coastal planning and decision-making.

To define the susceptibility of the coast and both tangible and intangible assets to coastal hazards (including inundation and erosion) it is important to identify the different forms these hazards may take and therefore how they may impact the region. Complex interactions between atmospheric, oceanic and terrestrial processes result in both short term and long term coastal change. Furthermore, consideration should be made where there are interactions between coastal and riverine hazards that the dominant hazard be identified and considered as the primary cause of any potential impacts

The principal hazards of erosion and inundation occur when dynamic coastal processes, often heightened by an extreme weather event, affect the coast. They can result in damage to the built environment, environmental degradation and in extreme cases loss of life. The impacts are generally greatest where the shoreline has been modified and developed to accommodate infrastructure or settlements.

Tropical cyclones can result in erosion and inundation, but erosion can also be a long-term process resulting in the recession of the shoreline along with permanent inundation of the foreshore. Slower, more gradual processes such as sea level rise will contribute to the likelihood of coastal hazards occurring.

Figure 4-1 Coastal inundation and coastal erosion arise from intricate interactions between several drivers. Source: Adapted from New Zealand Ministry for the Environment 2004

Table 4-1 presents an overview of the short and long-term hazards that may affect the coastline of the Bundaberg Region. Each hazard has been described in terms of a Source – Pathway – Receptor model[7]. Examples of issues and impacts to the potential Receptors (coastal asset categories of Receptors described in Section 4.3) have been drawn from the Workshop held in May 2016 examining current and future Council issues on the coast.

[7] Modelled on the State of Victoria, 2012, Victorian Coastal Hazard Guide (Section 8) and State of Western Australia 2014, Coastal hazard risk management and adaptation planning guidelines (Section 2).

Table 4-1 Coastal Hazards and Potential Impacts

Hazard	Source	Pathways	Potential Receptor	Impact / Issue
Long term coastal inundation	Sea level rise	Direct inundation of low-lying land especially in estuarine and coastal lagoons Inundation via rivers, streams or stormwater outlets.	Environmental Social Economic Utilities Marine infrastructure	Mangrove losses leads to flying fox displacement Septic and sewage issues - long term high water tables Evacuation routes from coastal communities cut Long term asset sustainability Loss of property, infrastructure and agricultural land
Temporary coastal inundation	Sea level rise Waves Climate cycles Wind	Overtopping or breaching of dunes, coastal barriers or protection works Inundation via beach access points and boat ramps Inundation via rivers, streams or stormwater outlets.	Environmental Social Economic Utilities	Roads shut during intense events Phone black spots and NBN / internet operability Inundation of built assets and disruption of services Fish kills in coastal lagoons Groundwater / septic /sewerage issues
Short term erosion	Waves Interrupted sediment supply Catchment discharges Climate cycles Wind	Short-term fluctuations/cycles River/coastal dynamics Human induced changes Can lead to long term continuous retreat especially for soft rock coasts	Environmental Social Economic Utilities Marine infrastructure	Foreshore embellishments -managing community expectations Turtle nesting Tourism Access both pedestrian and 4WD Loss of access to foreshore

Hazard	Source	Pathways	Potential Receptor	Impact / Issue
Long term erosion (soft shores)	Sea level rise Waves Interrupted sediment supply Catchment discharges Climate cycles Wind	Long-term continuous retreat Long term fluctuating recession Human induced changes	Environmental Social Economic Utilities Marine infrastructure	Impacts on liveability Potential loss of infrastructure and built assets Access to critical infrastructure Access to foreshore
Long term erosion (Rock shores)	Geological defects controls Sea level rise Waves Climate cycles Wind	Lowering of shore platform or fronting beach Internal factors (defects) Weathering	Environmental Social Economic Utilities Marine infrastructure	Slumping and undermining Removal of toe material Potential loss of infrastructure and built assets Non-asset solutions Council cannot fix everything
Damage to engineered coasts	Sea level rise Waves Interrupted sediment supply Catchment discharges	Overtopping Outflanking Increased wave forces	Environmental Social Economic Utilities Marine infrastructure	Undermining of existing structures People undertaking their own foreshore works Long term asset management and medium-term sustainability

4.3 Coastal Assets

Mapping of both Council and non-council assets which lie within the Coastal Management District (CMD) is presented on the mapping portal. This has brought together both Council and non-Council asset data for the Bundaberg Region, along with the erosion prone mapping and storm tide inundation overlays.

The CMD is presented on the mapping portal as a potential boundary for coastal asset identification. The CMD area considers the declared erosion prone area mapping which includes a projected sea level rise from climate change. of 0.8m to 2100. The CMD mapping generally includes lots permanently inundation by tidal wter.

Table 4-2 outlines the types of asset considered along with their functions and values. The assets include both tangible and non-tangible assets and are likely to be owned by a range of organisations, including Council and external stakeholders. Phase 4 of the CHAS will identify in detail the assets, the potential impacts to the assets and their owners.

Table 4-2 Coastal Asset Categories, Function and Value

Assets	Functions/Service and values
Environment	
Foreshore and beaches	Coastal access, recreation and conservation. Tourist drawcard. Habitat for flora and fauna (conservation for rare and threatened species). Supports biodiversity and ecosystem integrity. Important geo-morphological features. Buffer to other 'higher value' assets.
Estuaries	Access, recreation and conservation. Private agricultural land. Habitat for flora and fauna (conservation for rare and threatened species). Supports biodiversity and ecosystem integrity. Important geo-morphological features.
Social and Cultural	
Surf Life Saving clubs	Strong community attachment and service
Caravan parks	Provides local employment. Tourist drawcard. Seasonal population. Contributes to local economy.
Foreshore reserve amenity – dual use paths, toilet/picnic facilities, access paths/steps	On-going access and recreation.
Residential (existing/future) development	Provides housing for resident population and future population. Holiday accommodation for visitors.
Facilities - Hospitals, schools, aged care facilities	Provides essential services, local employment
Cultural and heritage features	Community attachment and history
Economic	
Roads, bridges, railways, car parks, public transport	Provides transport services
Harbours, jetties, boat ramps	Provides recreation facilities. Provides local employment. Contributes to local economy.
Commercial/industrial/institutional development and infrastructure	Provides employment and contributes to economy.
Agriculture	Provides employment and contributes to economy

Assets	Functions/Service and values
Utilities	
Stormwater outlets and pipes, flood mitigation	Provides essential services
Telecommunications	Provides essential services
Electricity and Gas	Provides essential services
Water and sewage management	Provides essential services
Marine Infrastructure	
Harbours, jetties, boat ramps	Provides recreation facilities.
Breakwaters, groynes and seawalls	Provides services

The mapping portal illustrates that when considering the existing data available related to the current projections for Queensland's coastline by 2100 that there are areas of the Bundaberg Region coastline that are potentially vulnerable to the impacts of projected climate change. However, as Table 4-1 also illustrates, the coastal communities also face existing coastal hazards in terms of inundation and short term coastal erosion which will likely be exacerbated in the future. The CHAS will need to consider the impacts of existing coastal hazards and those which will emerge over time.

5 ZONED LAND REVIEW

5.1 Exposure Analysis

An analysis of coastal hazard exposure based upon planning scheme zonings has been undertaken at a Statistical Area[8] (SA) 2 level for the localities and surrounding areas of:

- Ashfield – Kepnock;
- Bargara, Burnett Heads, Innes Park and Elliott Heads;
- Branyan – Kensington;
- Bundaberg CBD;
- Bundaberg East – Kalkie;
- Bundaberg North – Gooburrum;
- Moore Park Beach and surrounds;
- Woodgate Beach, Buxton and surrounds; and
- Millbank – Avoca.

The mapped extent of potential storm tide inundation and/or erosion is largely limited to rural and/or environmental management or open space zonings in the localities of Ashfield-Kepnock, Branyan-Kensington and Millbank-Avoca. To this end, these localities do not form part of the discussion below.

Impacts on strategic port land are identified in the sections below however, it is noted this is raised for awareness purposes only and likely the responsibility of other entities outside of Council to address.

5.1.1 Bargara, Burnett Heads, Innes Park and Elliott Heads

The coastal settlements of Bargara, Burnett Heads, Innes Park and Elliott Heads are located on a stretch of Bundaberg's coastline south of the Burnett River and north of the mouth of the Elliott River, east of Bundaberg. In addition to mixed density residential, these communities also provide a significant tourism role within the region including a range of short term accommodation facilities as well as supporting uses and facilities such as retail, entertainment and recreation services. These communities take on a separate identity to that of the balance of the region, supported by an inter-urban break which consists primarily of rural and agricultural land uses.

Outside of the City of Bundaberg, Bargara is the main service centre for the central coastal urban areas between Burnett Heads and Elliott Heads, and is the most populated community outside of Bundaberg with over 6,800 permanent residents. This is followed by Burnett Heads (over 2,700 residents), Innes Park (over 2,000 residents) and Elliott Heads (approximately 1,000 residents)[9]. Large public foreshore parks remain a key characteristic of each settlement, each of which are identified to '*accept significant levels of urban growth*' into the future under the *Central Coastal Urban Growth Area Local Plan* in the Bundaberg Regional Council Planning Scheme 2015[10].

[8] Statistical Areas are a standard hierarchy of geographic units used by the Australian Bureau of Statistics to define areas of different scales for communicating different data. The SA2 geographic scale approximates suburbs, or a collection of several suburbs.
[9] Bundaberg Regional Council Planning Scheme – Strategic Framework, pp. 3-2
[10] Bundaberg Regional Council Planning Scheme – Strategic Framework, pp. 3-11

As demonstrated by Table 5-1 below, both the environment management and strategic port land zones within this locality are identified as potentially subject to storm tide inundation, relevant to over 40 per cent of land within each respective zone. This is followed by land within the sport and recreation, high density residential and open space zones, based upon percentage of land subject to potential exposure within each zone. Smaller extents of other zones are also subject to potential storm tide inundation.

Table 5-1 Zoning exposure analysis for Bargara, Burnett Heads, Innes Park and Elliott Heads

Zone (Bundaberg Planning Scheme)	Bargara, Burnett Heads, Innes Park & Elliott Heads				
	TOTAL AREA PER ZONE	Storm tide Inundation		Erosion Prone Area	
		Area (ha)	%	Area (ha)	%
Low density residential	850.38	14.02	1.65%	27.46	3.23%
Medium density residential	69.48	3.85	5.54%	15.61	22.46%
High density residential	46.75	6.26	13.39%	2.23	4.76%
Local centre	12.47	0.47	3.75%	1.70	13.63%
Community facilities	236.89	11.30	4.77%	67.88	28.65%
Open space	544.56	60.31	11.07%	105.36	19.35%
Environmental management	45.26	20.02	44.22%	30.29	66.92%
Sport and recreation	143.59	25.40	17.69%	26.93	18.76%
Limited development	44.52	2.37	5.33%	2.31	5.20%
Emerging communities	1028.33	18.80	1.83%	22.82	2.22%
Strategic port land	353.13	153.74	43.54%	174.33	49.37%

Likewise for land identified as erosion prone, Medium density residential, local centre and community facilities zones represent those with existing and future potential to accommodate urban development which are currently mapped to include significant portions of potential exposure.

5.1.2 Bundaberg CBD

The Bundaberg CBD is the primary business, service, civic and administrative centre for the region with a riverfront location alongside the Burnett River. The Bundaberg CBD is relatively close to the mouth of the Burnett River, approximately 15 kilometres upstream. This proximity thus gives rise to the need to consider potential storm tide inundation and erosion impacts upstream, as relevant to the CBD.

As identified as Table 5-2 below, the residential areas of the CBD are not identified via current mapping as subject to potential impact however, potential impact on areas within the Principal centre zone are identified with approximately 2.5 per cent of land in this zone mapped as subject to storm tide inundation hazard, and over 10 per cent mapped as subject as a potential erosion prone area. A small portion of land within the community facilities zone is also mapped as subject to potential impact. Higher portions of land within non-urban zones such as the open space and limited development zones are also identified by current mapping.

Table 5-2 Zoning exposure analysis for the Bundaberg CBD

Zone (Bundaberg Planning Scheme)	Bundaberg CBD				
	TOTAL AREA PER ZONE	Storm Tide Inundation		Erosion Prone Area	
		Area	%	Area	%
Low density residential	97.14	0.00	0.00%	0.00	0.00%
Medium density residential	82.78	0.00	0.00%	0.00	0.00%
High density residential	4.94	0.00	0.00%	0.00	0.00%
Neighbourhood centre	5.76	0.00	0.00%	0.00	0.00%
Local centre	1.59	0.00	0.00%	0.00	0.00%
Principal centre	48.95	1.23	2.52%	5.11	10.44%
Specialised centre	10.22	0.00	0.00%	0.00	0.00
Community facilities	69.16	0.29	0.42%	0.93	1.34%
Open space	65.73	21.35	32.49%	31.23	47.51%
Sport and recreation	15.87	0.01	0.05%	0.88	5.52%
Limited development	17.93	0.70	3.88%	2.36	13.16%
Strategic port land	2.48	2.05	82.60%	2.48	100.00%

5.1.4 Bundaberg East – Kalkie

Bundaberg East and Kalkie are located to the immediate east of the Bundaberg CBD, comprising a mix of residential, commercial and industrial activities surrounded by rural land uses. The locality is bound by the Burnett River to the north and incorporates part of Baldwin Swamp Environment Park, which connects with the Burnett River, to the south-west. Part of the suburb of Kalkie is included within the Kalkie-Ashfield Local Development Area and is poised for continued urban residential growth under the Planning Scheme.

The zoning exposure analysis undertaken at Table 5-3 illustrates over 50 per cent of land within the principal centre zone in this locality is mapped as an erosion prone area. Approximately 6 per cent of land within the Industry zone is also mapped as subject to potential erosion impact.

Table 5-3 Zoning exposure analysis for Bundaberg East - Kalkie

Zone (Bundaberg Planning Scheme)	Bundaberg East - Kalkie				
	TOTAL AREA PER ZONE	Storm Tide Inundation		Erosion Prone Area	
		Area	%	Area	%
Low density residential	227.25	0.00	0.00%	0.00	0.00%
Neighbourhood centre	2.12	0.00	0.17%	0.00	0.08%
Principal centre	1.83	0.07	3.88%	0.95	51.81%
Specialised centre	7.42	0.02	0.20%	0.02	0.26%
Industry	112.58	1.32	1.18%	6.72	5.97%
Rural	193.35	14.57	7.54%	16.70	8.64%
Community facilities	68.29	0.39	0.57%	0.81	1.19%
Open space	50.70	5.25	10.35%	5.75	11.35%
Sport and recreation	35.05	11.67	33.30%	2.98	8.51%
Emerging communities	430.58	12.46	2.89%	20.03	4.65%
Limited development	9.56	0.01	0.07%	0.00	0.00%

5.1.5 Bundaberg North – Gooburrum

Bundaberg North, Gooburrum and surrounds are located to the north and north-east of the Burnett River as it meanders the landscape between the Bundaberg CBD and the coastline. North Bundaberg is connected to the CBD via three cross-river bridges and accommodates a mix of land uses including low density residential, commercial, industrial and open space. Community facilities including schools are located in the area, as is aged care. The suburb of North Bundaberg was significantly impacted by the 2013 ex-TC Oswald flood event which saw significant damage to buildings and infrastructure.

A portion of industrial zoned land is identified as an erosion prone area as well as a very small amount of land zoned for Low density residential and Local centre (similarly for storm tide inundation). Most erosion prone land which is currently mapped is zoned for non-urban uses with the exception of strategic port land.

Table 5-4 Zoning exposure analysis for Bundaberg North - Gooburrum

Zone (Bundaberg Planning Scheme)	Bundaberg North - Gooburrum				
	TOTAL AREA PER ZONE	Storm Tide Inundation		Erosion Prone Area	
		Area	%	Area	%
Low density residential	235.00	0.16	0.07%	2.31	0.98%
Neighbourhood centre	0.37	0.00	0.00%	0.00	0.00%
Local centre	11.31	0.02	0.17%	0.01	0.13%
Specialised centre	0.92	0.00	0.00%	0.00	0.00%
Industry	41.35	1.17	2.82%	5.71	13.81%
Strategic port land	3.76	3.28	87.10%	3.76	100.00%
Rural	3450.26	165.98	4.81%	206.97	6.00%
Rural residential	684.31	0.77	0.11%	3.26	0.48%
Community facilities	93.43	4.02	4.30%	4.03	4.32%
Open space	101.69	25.47	25.04%	38.76	38.11%
Sport and recreation	63.40	0.56	0.89%	0.00	0.00%
Emerging communities	76.82	0.00	0.00%	0.00	0.00%
Limited development	101.11	4.89	4.84%	11.20	11.07%

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5.1.6 Moore Park Beach and Surrounds

Moore Park Beach is a small, coastal lifestyle residential settlement north of the mouth of the Burnett River and south of the Kolan River, approximately 15 kilometres north of Bundaberg. Surrounded by rural land uses and other smaller settlements, Moore Park Beach maintains a resident population of over 1,900 persons and incorporates a range of land uses which support the local resident population. The Planning Scheme seeks to largely maintain the current urban form of the locality, it is not earmarked for extensive urban expansion.

As highlighted by the zoning exposure analysis below, a significant portion of land zoned for low density residential, medium density residential and local centre is mapped as subject to potential storm tide inundation and coastal erosion.

Table 5-5 Zoning exposure analysis for Moore Park Beach and surrounds

Zone (Bundaberg Planning Scheme)	Moore Park Beach & Surrounds				
	TOTAL AREA PER ZONE	Storm Tide Inundation		Erosion Prone Area	
		Area (ha)	%	Area (ha)	%
Low density residential	273.35	37.07	13.56%	50.17	18.35%
Medium density residential	14.27	4.44	31.15%	4.47	31.31%
Local centre	10.19	3.61	35.43%	4.37	42.89%
Community facilities	890.76	89.08	10.00%	96.24	10.80%
Rural	100683.76	8115.39	8.06%	8990.58	8.92%
Open space	281.63	130.11	46.20%	161.41	57.31%
Environmental management	11680.11	1157.60	9.91%	1285.98	11.01%
Sport and recreation	32.41	0.50	1.55%	2.64	8.16%
Emerging communities	0.00	0.00	0.00%	0.00	0.00%

5.1.7 Woodgate Beach, Buxton and Surrounds

The localities and Woodgate, Buxton and surrounds is located south of Elliott Heads and north of Burrum Heads and the Isis River. Woodgate Beach is a small coastal settlement of less than 1,000 persons which provides a diversity of land uses which support the local population and periodic tourist populations. Likewise, Buxton is a small coastal settlement of over 400 persons in the southern area of the Bundaberg Region, located on the Isis River approximately 7 kilometres from the river mouth. The Isis River is over a kilometre wide at its mouth, turning sharply south in the area where the Buxton settlement is located. It is for this reason Buxton is considered a coastal rather than an inland community. The balance of the surrounding area largely comprises rural land uses.

Significant portions of land currently zoned for low density residential, medium density residential and neighbourhood centre are mapped as potentially subject to storm tide inundation and coastal erosion impact, including over 40 per cent of them medium density residential zone for storm tide inundation. In terms of area of land, over 15 hectares within the rural residential zone is identified as subject to potential storm tide inundation and over 22 hectares is identified as erosion prone. Whilst this represents only a small area of the overall rural residential zone, the area of land zoned for rural residential purposes across the area is substantial.

Table 5-6 Zoning exposure analysis for Woodgate Beach, Buxton and surrounds

Zone (Bundaberg Planning Scheme)	Woodgate, Buxton & Surrounds				
	TOTAL AREA PER ZONE	Storm Tide Inundation		Erosion Prone Area	
		Area (ha)	%	Area (ha)	%
Low density residential	478.61	57.57	12.03%	56.35	11.77%
Medium density residential	35.57	14.35	40.34%	12.91	36.28%
Neighbourhood centre	4.67	0.54	11.50%	0.61	12.98%
Community facilities	3153.76	19.13	0.61%	15.18	0.48%
Open space	579.94	244.32	42.13%	255.50	44.06%
Environmental management	69948.69	1551.20	2.22%	1424.31	2.04%
Sport and recreation	32.41	0.50	1.55%	2.64	8.16%
Emerging communities	0.00	0.00	0.00%	0.00	0.00%
Rural residential	3532.86	15.62	0.44%	22.32	0.63%

6 SOCIO AND DEMOGRAPHIC REVIEW

6.1 Socio Demographic Vulnerability Analysis

A socio-demographic analysis of vulnerability has been undertaken, again at the SA2 level, for populations identified as subject to potential exposure. A vulnerability analysis of the Bundaberg CBD was not conducted, given the limited potential exposure identified in Section 5.1.2.

In terms of understanding potential socio-demographic vulnerability, a number of indices were analysed which inform potential issues in the ability to evacuate or the ability to take personal action or invest in mitigation to enhance household resilience, for example.

The socio-demographic vulnerability indicators used in this study (which are non-exhaustive and intended only for the purposes of scoping potential concerns) are drawn from the 2011 Australian Census and the Office of the Queensland Government Statistician, as shown in Table 6-1.

Table 6-1 Socio-demographic Vulnerability Criteria

Criteria	Description & Source
Child dependency ratio Age dependency ratio	Child and Aged dependency ratios have been derived from the Office of the Queensland Government Statistician and provide an indicator of the extent of young and old persons relative to the general population within an area.
SEIFA index	The Socio-economic Indexes for Areas (SEIFA) data provided by the ABS – specifically the Index of Relative Socio-Economic Disadvantage (IRSD) – is an indicator of social disadvantage that summarises a range of information about the economic and social conditions of people and households within an area – higher SEIFA scores indicate higher socio-economic area, while lower scores reflect lower-socioeconomic areas.
Core activity need for assistance ratio	Core activity need for assistance data is collected as part of the 2011 Australian Census and provides an indication of infirm persons who rely on others for day to day activities within an area (including persons who are infirm, disabled, and the like).
Number of vehicles per dwelling ratio (% of zero vehicles)	Number of motor vehicles per dwelling is collected as part of the 2011 Australian Census and is useful in considering the self-evacuation capability of residents. The metric used is a ratio of dwellings with zero vehicles in the area of study relative to the total number of dwellings.

6.1.1 Bargara, Burnett Heads, Innes Park and Elliott Heads

As demonstrated below, the communities of Bargara, Burnett Heads, Innes Park and Elliott Heads are generally consistent with the LGA average with respect to child dependency and SEIFA disadvantage index, and presents a lower number of dwellings with zero vehicles than the LGA average, and a slightly lower number of disabled or infirm persons. The SA2 does however, include a higher rate of aged dependency when compared with the LGA average, indicating a more pronounced cohort of older residents in the locality against other age groups.

Table 6-2 Analysis of vulnerability indicators for Bargara, Burnett Heads, Innes Park and Elliott Heads

Bargara, Burnett Heads, Innes Park & Elliott Heads	Vulnerability indicators	
	Value	Comparison to LGA average
Child dependency ratio	31.6	30.8
Aged dependency ratio	42.6	37.6
SEIFA disadvantage index	977	930
Disabled/infirm persons	6.08%	7.24%
% zero vehicles per dwelling	4.55%	7.08%

6.1.2 Bundaberg East – Kalkie

The Bundaberg East – Kalkie community exhibits largely consistent characteristics with that of the broader LGA with respect to the SEIFA disadvantage index and the number of dwellings with zero vehicles, and a slightly lower number of disabled / infirm persons. Likewise, the locality exhibits a lower number of aged residents per 100 persons than the broader LGA. In terms of child dependency, the locality exhibits a higher rate compared with that of the LGA.

Table 6-3 Analysis of vulnerability indicators for Bundaberg East – Kalkie

Bundaberg East - Kalkie	Vulnerability indicators	
	Value	Comparison to LGA average
Child dependency ratio	36.5	30.8
Aged dependency ratio	32.7	37.6
SEIFA disadvantage index	963	930
Disabled/infirm persons	6%	7.24%
% zero vehicles per dwelling	7.30%	7.08%

6.1.3 Bundaberg North – Goomburrum

The communities of Bundaberg North – Goomburrum is generally consistent with the LGA averages for all socio-demographic vulnerability indicators selected, with the exception of the ration of aged dependency. The cohort of aged residents within this locality is considerably higher than that reflected within the broader LGA.

Table 6-4 Analysis of vulnerability indicators for Bundaberg North - Goomburrum

Bundaberg North - Goomburrum	Vulnerability indicators	
	Value	Comparison to LGA average
Child dependency ratio	29.2	30.8
Aged dependency ratio	48.7	37.6
SEIFA disadvantage index	933	930
Disabled/infirm persons	8%	7.24%
% zero vehicles per dwelling	7.90%	7.08%

6.1.4 Moore Park Beach and Surrounds

The communities of Moore Park Beach and surrounds do not appear to indicate any particular socio-demographic characteristics which may give rise to potential vulnerability, having consideration to those indicators analysed below. The communities appear to remain either consistent with, or lower than, the broader LGA averages for child and aged dependence, SEIFA disadvantage, disabled / infirm persons and dwellings with zero vehicles.

Table 6-5 Analysis of vulnerability indicators for Moore Park and surrounds

Moore Park & Surrounds	Vulnerability indicators	
	Value	Comparison to LGA average
Child dependency ratio	26.4	30.8
Aged dependency ratio	31.5	37.6
SEIFA disadvantage index	957	930
Disabled/infirm persons	6%	7.24%
% zero vehicles per dwelling	1.60%	7.08%

6.1.5 Woodgate Beach, Buxton and Surrounds

Similar to Moore Park Beach and surrounds, the communities of Woodgate Beach, Buxton and surrounds appear to be either consistent with the broader LGA with respect to each of the indicators analysed, or exhibit lower values than the LGA average.

Table 6-6 Analysis of vulnerability indicators for Woodgate Beach, Buxton and surrounds

Woodgate, Buxton & Surrounds	Vulnerability indicators	
	Value	Comparison to LGA average
Child dependency ratio	25.3	30.8
Aged dependency ratio	37.4	37.6
SEIFA disadvantage index	931	930
Disabled/infirm persons	6.68%	7.24%
% zero vehicles per dwelling	3.95%	7.08%

7 NEXT STEPS

7.1 Summary of strategic issues

The ability to address the many challenges associated with disaster recovery and climate change adaptation requires several key actions. These include:

- Investing more resources in pre-event planning and policy that emphasise building and sustaining the capacity of assistance networks. Our current approach to drop large sums of funding and technical assistance into communities after a disaster strikes does little to increase local capacity. Instead, it continues to foster dependence rather than striving to increase local self-reliance (an important, but often overlooked aspect of resilience). This perverse incentive can encourage development in known high-hazard areas with little in the way of local accountability.
- Developing plans that are actionable (and measurable, refer to emerging disaster recovery indicators literature) can be used to gradually enhance local accountability.
- As plans mature and improve over time, communities, states, and the federal government should all be held to increased standards of performance. Among key standards worthy of pursuit include the development of robust disaster recovery, hazard mitigation and climate change adaptation plans that effectively confront uncertainty. This will require confronting and altering policies and planning initiatives that hinder the aims of resilience.
- Being prepared to capitalise on the post-disaster window of opportunity to affect positive change as agreed to by well-established networks is also important and should be an important part of a community's pre-event planning. This may include, for instance, addressing at-risk structures and community vulnerability through post-disaster risk reduction programs like the relocation of flood-prone dwellings and infrastructure out of harm's way.
- In the case of coastal communities, it is incumbent on networks to take actions now to advance resilience, to include bold steps that account for the uncertainties of climate change.

7.2 Need to develop a CHAS

This scoping study has demonstrated that there are and will likely be coastal hazard issues which will impact the community in the Bundaberg Region. The mapping portal illustrates the quantity of coastal assets that are within the Coastal Management District and fall within the existing erosion prone area and storm tide inundation mapping. The zoned land review has demonstrated percentage of land subject to potential exposure within each zone across the region. The socio-demographic review has provided an indication of the potential vulnerability of the community.

As a consequence, there will be a need to further understand the likelihood and consequence of coastal hazards having an adverse impact on Council operations and community assets and to seek ways through adaptation planning to reduce future exposure to risks of coastal flooding, storm tides and erosion. This will enable Council to plan for both the short term and longer term needs of the community to maintain where required the built and natural environment and the services within the at risk areas.

7.3 Council’s future needs and governance

Adaptive actions will need to be embedded across core governance functions in Council. This will include all It is unlikely that current practice or ‘business as usual’ will not be sufficient to enable Council and non-Council assets and services to adapt to climate change in the future. It is possible that existing instruments, plans, processes and other tool will require modification or even be created to integrate and deliver adaptive options.

Council has prepared a draft governance structure to lead and guide the development of the CHAS and its implementation. The aim of this is to ensure ‘buy in’ across Council departments. By involving a wide range of Council functions from the outset, the work in Phase 8 which brings together the strategy development, implementation and review with any internal organisational change management plan designed to provide a structured and systematic way to guide the implementation of the CHAS can be facilitated

Phase 4 of the CHAS process will assist in furthering the discussion on considering what different Council departments will require from the CHAS to support their decision-making needs, this is particularly relevant in terms of future asset upgrades. By understanding the impacts of coastal hazards on individual tangible and non-tangible assets, plans can be formulated, consulted on, and agreed on to manage the coastal region of Bundaberg in such a way that considers both priority, economic requirements and sustainability.

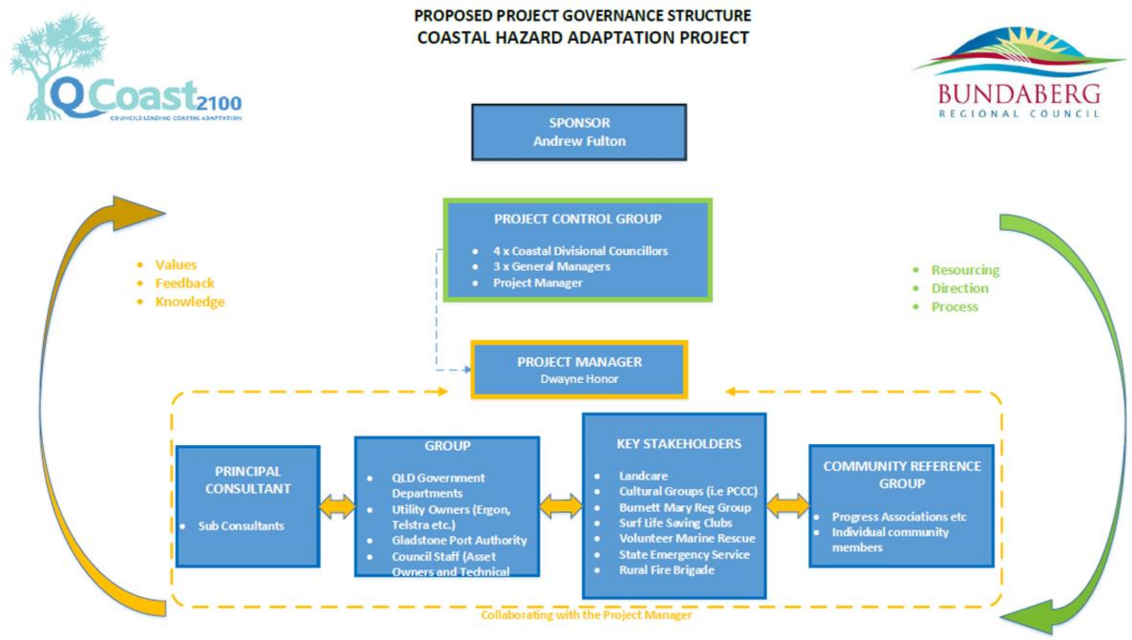

Figure 7-1 Proposed Project Governance Structure

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7.4 Planning horizons

It is recognised that the potential impacts of climate change will present challenges to the Bundaberg Region and its communities, businesses and natural environment. To assist with the adaptation planning for the Bundaberg Region it is proposed that rather than focus on absolute planning horizons in terms of dates/years into the future, the CHAS develops unique, location based trigger points.

The trigger points can be set to identify the level of acceptable change before adaptation planning or options must be implemented. This will reflect that in most cases, there is likely to be more than one way to adapt to climate change at different points in time. Different responses may also be preferred to reflect how climate change projections, societal values and other parameters will change through time.

7.5 Further investigations

In broad terms, the use of coastal hazard data and its quality should be looked at through two lenses:

1. The ability to investigate and proposed policy and adaptation responses and the depth to which such an analysis can be undertaken; and
2. The information communicated to the community that both characterises the nature of the hazard/risk and justifies the nature of the policy responses proposed.

Naturally, the more detailed data that is available, the wider range of adaptation options that can be considered – particularly in terms of fully understanding the spectrum of risk and the characteristics of the hazard (temporally, spatially and hydraulically/geologically). Where data or the quality of the data is limited, it limits the ability to make more adventurous or advanced policy/adaptation decisions. A case in point is the QFAO flood data prepared by the State government – given it is only indicative in nature, it is not suitable for hazard-based analysis, land use planning policy making or risk management decision-making. More detailed flood modelling by contrast would be able to provide the data required to undertake these measures.

It is noted the term ‘quality’ is meant to refer to aspects such as ‘granularity’ (i.e. is the data course or fine) and extent (is it comprehensive in scale and matters addressed) rather than technical competency. Further, involvement of the community in risk management and adaptation decision-making, which is the critical component of community-driven development practices, can lead to unsuccessful engagement and project outcomes where:

- The community does not ‘believe’ the data;
- The data is not ‘best practice’ – ‘best available’ tends not to be sufficient where significant potential for adverse impact exists; and
- Significant policy changes or adaptation options are proposed – where the community feels adverse impact exists, our experience has been they will question the mapping/modelling/data first and foremost, rather than the policy options themselves. However, this in turn reduces the legitimacy of the policy/adaption options being proposed.

The ‘accuracy’ of hazard data is a common concern for the community when hazard information is released to the public. Hazard data provided to the public can often be not well received – particularly where it may not accurately represent the latest or a major flood a person has experienced (such as where previous inundation or erosion events have not been as severe as the modelled events). Residents can have trouble ‘believing’ this data, which can create significant community backlash. Being able to communicate that the data represents ‘best practice’ rather than ‘best available’ is an important mitigation method for this backlash.

Council should therefore be confident in the accuracy of the data it releases and uses to develop the hazard and risk information to be communicated, including the accuracy/suitability/currency of the inputs such as hydrology, geology and elevation data. Where there are concerns over the accuracy of this information, Council should decide whether to release the data for public review, and scope back the available policy/adaptation options for investigation/testing accordingly. If released, Council should also have a message for people who query that accuracy, noting that the data will be updated periodically as part of normal operations. However, if the data is to be relied upon for significant decisions such as selecting mitigation/management measures, obtaining more detailed data/re-running models should be considered.

7.5.1 Spatial data review

During the process of creating the mapping portal it became apparent that some of Council's existing data sets are likely to require a more detailed review. This is to ensure that all tangible and intangible asset data can be utilised in Phase 4 of the CHAS where the key assets potentially impacted are assessed and analysed in detail.

7.5.2 Storm tide inundation

The gap analysis of current technical knowledge (discussed in Section 3.4) has identified that the currently defined storm tide inundation extents along the coastline of the Bundaberg LGA do not consider dynamic effects, are likely to be too coarse a scale across coastal urban areas, and the accuracy of the available terrain data is unknown.

The accuracy of available terrain data for modelling and mapping could also be reviewed. We understand that new terrain data has been gathered recently and this could be compared with the existing data. The existing storm tide levels could be remapped onto the new terrain data a finer grid scale to resolve topographic features and limit the effects of smoothing, as well as remove wave setup and runup estimates from the mapped extents.

To enable the assessment of potential trigger levels of threshold for adaptation responses it is necessary to consider the effects of a range of increments of sea level rise (and other future climate effects), not just a single scenario. At present, all coastal flooding related studies relevant to this study area only consider a single sea level rise increment of 0.8 metres. This applies to both the technical as well as economic assessments. This additional information could be obtained by undertaking a mapping exercise to interpolate the existing data and provide additional sea level rise incremental impact data to support the study.

7.5.3 Shoreline erosion

The gap analysis of current technical knowledge has identified that the currently defined erosion prone areas along the coastline of the Bundaberg LGA consider only the effects of a single ARI storm event and a sea level rise of 0.8 metres only.

To be effective, future stages of the CHAS should consider the effects on shoreline erosion across a range of design events to determine the relationship between the vulnerability and the hazard level (i.e. the topographic distribution of assets). Furthermore, to assess potential trigger levels or thresholds for adaptation responses, it will be necessary to consider the effects of a range of sea level rise increments (and other future climate effects), not just a single scenario. This applies to both technical as well as economic assessments.

The erosion hazard is significantly aligned with long-term ocean water levels. Notwithstanding the timescales, small changes in average sea level can have a substantial effect on erosion processes along many of the coastal reaches of the Bundaberg LGA – particularly in areas of low topography such as Moore Park Beach and Woodgate Beach. The distribution of assets within foreshore areas may be such that they become exposed to shoreline erosion as a consequence of quite modest sea level rise. However present knowledge regarding the erosion hazard is limited to a single sea level rise scenario of 0.8 metres.

It is relevant to note that another recommendation of the Learnings Report which evolved from the Townsville CHAS Pilot Project (Table 2 of that document) is:

- Sea level rise and erosion surfaces should be produced for a number of different years during the planning period to provide a smoother transition

It is for this reason that current knowledge regarding the emerging impacts of shoreline erosion with future sea level rise is considered a shortcoming in delivering reliable outcomes of the CHAS. An appropriate understanding of shoreline erosion under different scenarios of future sea levels (and different storm/cyclone intensities) can be obtained without the need to undertake sophisticated or expensive numerical modelling. There are several proprietary beach response models available that can be readily used for assessments of local storm-induced erosion. These could be applied to better define the erosion threat along critical "at-risk" foreshores – which could be prioritised for assessment as future stages of the CHAS evolve.

7.5.4 Marine infrastructure

At locations along the foreshore, mitigation of the existing erosion threat relies on various seawalls, groynes, breakwaters and river entrance training walls. However, whether these structures are currently fit-for-purpose and robust enough to accommodate future conditions is unknown. To better determine the role that such infrastructure might play in future erosion mitigation strategies, it will be necessary to undertake an audit of each structure.

Such audits should not only consider the structural integrity of the asset, but also its effectiveness as a component in the overall strategy of foreshore protection. For example, an audit of rock-armoured groynes at Burnett Heads, Bargara and Elliott Heads should not only investigate the structural robustness of the groynes, but also whether they will continue to serve their intended purpose of retaining stable beach compartments in future.

7.5.5 Summary of further investigations

The cost of additional investigations can be substantial. When determining where along the coastline more detailed investigations of the inundation hazard might be undertaken, considerations need to include:

- the environmental, social and cultural, and economic values of the at-risk foreshore and backshore areas;
- whether the foreshore and backshore has future development potential;
- the likely timeframes for future determinations of development and/or rezoning;
- the quality and extent of available data to inform any re-assessment.

There would appear to be considerable merit in undertaken refined mapping of future storm tide hazard along the at-risk shoreline of the LGA to support the CHAS development. This would provide improved input to an updated inundation hazard analysis and enable a better understanding of potential impacts relating to trigger points in the future. The cost of such refined mapping and analysis is likely to be in the range of $10,000 to $20,000 depending, on the geographical extent and level of mapping resolution required.

Furthermore, there would appear to be considerable merit in undertaking further investigations of the existing and future erosion hazard along the at-risk 'soft' foreshores of Woodgate Beach, Elliott Heads, Innes Park, Mon Repos and Moore Park Beach given that it is likely that those locations will be key areas for consideration in terms of future adaptation planning. The community and other stakeholders will need confidence in the science behind any future predictions for the coastline. The cost of such technical assessments is likely to be in the range of $8,000 to $15,000 each, depending on their specific characteristics and geographical extent.

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APPENDIX A
KEY DETERMINANTS FOR SUCCESS

11th October 2016

BRC INTERNAL CHAS WORKSHOP

KEY DETERMINANTS FOR SUCCESS

Planning & Development

1. **Aligning CHAS outcomes with the Planning Scheme Responses**
   - Develop varying responses to hazards (I.e. river v creek c surge storm flooding).
   - Assess Priority Infrastructure Areas for climatic impacts (exposure and vulnerability), amend where required.
2. **Develop shared understanding of Exposure / Vulnerability and Resilience of existing infrastructure with the community.**
3. **Develop CHAS using Community Driven Development (CDD) principles and broad engagement to build co-ownership of complex problems and co-design of solutions.**
   - Develop cost estimates for implementation of CHAS recommendations in 2018/19 budget process.
   - Build institutional trust with local government processes (i.e. We will act on your consensus - bottom up, not top down)

Environmental

4. **Increase the "value" of natural assets within the community**
   - Improve understanding of the critical role natural assets have in buffering climatic impacts such as storm surge and coastal erosion vs their destruction and replacement with hard infrastructure.
5. **Develop a system for the community to visualise coastal hazards/risks and the impact of multiple adaptation responses over variable time periods. Examples include:**
   - Setback of property to rising sea levels and erosion prone areas
   - Increased floor levels and building designs within storm surge zones
6. **Connecting and aligning the CHAS to tangible Council responses (such as the SEMP).**

11th October 2016

Disaster Management and Resilience

7. **Develop a shared responsibility for adaptation with the Community.**
    - Educate impacts using easily interpreted visualisations
    - Develop shared consensus of issues and solutions via a facilitated process of engagement.
8. **Change community perception so that adaptation is understood to be 'normal business' where individuals have a responsibility to act as much as government.**
9. **Understanding the Psychology / Sociology of climate adaptation within the Community**
    - 'Start with People' as a core driver of success, use a human centred approach to the design of adaptation solutions
10. **Community safety and risk – existing / future**
    - Communication of "risk' is NOT communication of "Hazard'
    - Determine social exposure/vulnerability
11. **Address storm tide evacuation**
    - Integrating community behaviours into planned responses
12. **Develop and implement a tool to measure and assess community resilience to coastal hazards for the Bundaberg LGA**
    - Develop a baseline program to measure resilience over time and assess returns on Councils adaptive investments.
    - Measure at start and end of the CHAS process to determine what impact the process has had on understanding of issues, and changed behaviours within the community.

APPENDIX B
FIRST PASS STORM TIDE PROJECT SCORING

First Pass Storm Tide Project Scoring

First Pass Storm Tide Project Scoring Criteria		Score
1	**Climatological Analysis**	
1.01	Are the relevant storm surge producing events identified	Comprehensive
1.02	Are all datasets clearly defined and referenced	Yes
1.03	Has BoM advice been obtained	Not stated
1.04	Have temporal and spatial distributions of storm populations being determined	Comprehensive
1.05	Have scale and speed distributions of storm populations been determined	Comprehensive
1.06	Has the intensity of storm populations been determined	Comprehensive
1.07	Have synoptic scale interactions been considered	Not stated
1.08	Is parameterisation of the storm set explained and justified	Comprehensive
1.09	Has any base data been adjusted or corrected with justification	NA
1.10	Are inter-annual or inter-decadal variabilities discussed or considered	No
1.11	Is potential enhanced Greenhouse climate change considered	MSL, track, intensity, frequency
2	**Numerical Modelling – Atmospheric**	
2.01	Are the atmospheric models adequately disclosed and described	Basic
2.02	Are critical coefficients and assumptions relevant to this study disclosed?	Yes
2.03	Are example modelled storm system provided and explained	Comprehensive
2.04	Are the models shown to be calibrated and/or verified in similar contexts	Yes
2.05	Does the model consider overland decay or land interactions where relevant?	Basic
3	**Numerical Modelling – Oceanic / Hydrodynamic**	
3.01	Has suitably accurate bathymetric data been obtained	Yes
3.02	Has suitably accurate land elevation data been obtained	Yes, but there may be issues with the resolution in some areas
3.03	Do model extents and resolutions satisfy QCC recommendations	Extents – Yes Resolution – No for urban or development areas. Model grid resolution too coarse but not actually used for dynamic simulations
3.04	Are the hydrodynamic models adequately disclosed and described	Comprehensive except for description of bathy and topography.
3.05	Are critical coefficients and assumptions relevant to the study disclosed	Yes

First Pass Storm Tide Project Scoring Criteria		Score
3.06	Are example model outputs provided and explained	Basic
3.07	Are the models shown to be calibrated and/or verified in similar contexts?	Yes
3.08	Is surge-tide interaction considered?	Modelled
3.09	Is storm tide coincident with surface waves modelled	Yes, to derive parametric models
3.10	Is surge-wave interaction considered?	Yes
3.11	Is overland flow explicitly modelled?	No, not for design events
3.12	Is potential enhanced Greenhouse climate change considered	Interactions
3.13	Is freshwater river inflow considered	Yes for Burnett River, not for other coastal creeks/rivers
3.14	Is morphological modifications considered	No
4	**Statistical Modelling**	
4.01	What is the basis of the statistical method	Monte Carlo simulation
4.02	Are statistics derived from parameterised or full model representations	Parametric
4.03	Does the simulation period adequately over the required ARI estimates	Yes
4.04	How are the various storm population risks considered	Envelope
4.05	Is coupled tide, surge and wave modelling represented	Uncoupled
4.06	Is freshwater river inflow considered	No
4.07	Is there sensitivity testing of model assumptions	Yes
5	**Risk Assessment**	
5.01	Does the study provide storm tide estimates on an ARI basis?	Yes
5.02	Is wave setup or run-up included in the estimates	Setup and runup
6	**Documentation and Presentation**	
6.01	Does the study provide mapping	Static, and includes wave setup and runup for some locations within the inundation extent rather than as freeboard
6.02	Does the study provide an electronic dataset and/or analysis tools	Yes

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