Kelso Coastal Adaptation Pathways

Final Report

West Tamar Council, Tasmanian Climate Change office
March 2014

SGS Economics & Planning

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1 INTRODUCTION AND AIM

1.1 This report

The aim of this report is to inform residents and visitors of Kelso and the wider community about coastal risks in light of sea level rise resulting from climate change. It considers ways to respond to risks while also considering the values of living in Kelso and other benefits such as beach recreation, fishing and swimming.

A better understanding of the issues and possible responses will help the community to make informed decisions to respond to sea level rise and its potential impacts.

The report starts with an overview of the coastal hazards (inundation and erosion) at the present day and expected changes in the future as a result of expected sea level rise. The report then describes the potential damages that may occur as a result of sea level rise and extreme storm events. It also describes how likely it is that damages would occur, now and in the future.

While coastal risks may increase over time, the area exhibits a range of specific values, such as access to the beach, which make it attractive to live and recreate there. In deciding how to respond to sea level rise it is important to not only consider the risks but also the values or benefits of using the land. The report therefore considers any values that may be foregone if new development is prohibited or lost if existing development is required to retreat.

The final part of the report provides an overview of potential responses or pathways to respond to sea level rise. This last section considers those options that are potentially relevant in the Kelso area. It presents three possible pathways for adaptation. Each pathway explores a distinct way of adapting. The pathways are neither predictions nor recommendations. The section also includes the results from community workshops during which community members explored each pathway to understand how things may change and to determine a preferred way forward.

The final section includes recommendations for Council on the way forward from here.

1.2 Project background

The Tasmanian Coastal Adaptation Decision Pathways (or TCAP) extension project is a project established with funding from the Department of Premier and Cabinet's Tasmanian Climate Change Office and the Australian Government's Natural Disaster Resilience Program (NDRP), administered in Tasmania by the State Emergency Services. The project is managed by the Tasmanian Climate Change Office (TCCO) working cooperatively with three local government areas: West Tamar, Waratah-Wynyard and Central Coast, each of which is contributing to TCAP through both financial and in-kind support.

The TCAP extension project will apply the earlier developed and applied TCAP methodology and develop coastal adaptation pathways for local communities. This will be done for the vulnerable coastal areas of Kelso, Somerset and Turners Beach. The pathways will be developed by progressing to Step 9 along a 15 step process for flexible community adaptation planning (refer to 1.3). The focus of the TCAP extension project will be on short term adaptation pathways (to 2050), while also considering the longer term impacts (to 2100).

1.3 Coastal Climate Change Adaptation Pathways

Based on previous and ongoing work, SGS developed guidelines for communities and states for coastal climate adaptation pathways. The adaptation pathways cover approximately 15 steps in total and present a consultative approach involving the community, local and other government, land managers and other key stakeholders. The pathway approach does not prescribe a one-size-fits-all solution, but, as the word 'pathway' suggests, is a process to achieve adaptation responses.

It is anticipated that this study will progress West Tamar Council to approximately step 9 of the 15 step pathway. The 15 steps are as follows:

1. Establish hazards and future sea level rise effects and map at the local/relevant scale
2. Review of Draft interim planning scheme for coastal hazard areas
3. Assess assets at risk
4. Establish the expected cost of risk
5. Assess the value of occupation or use
6. First cut assessment of adaptation options and costs
7. Plan and implement necessary short term protection works in hazard areas
8. Establish preliminary policy and decision making framework
9. Strategic options assessment (Scenario Planning)
10. Detailed assessment of short listed options
11. Select preferred scenario
12. Establish financial framework
13. Revised 'final' planning scheme
14. Implementation
15. Review

Each section of this report relates to one of these 15 steps and this is identified at the start of each section. This report presents the results up to Step 6.

1.4 Kelso – project site introduction

Kelso is a small village in the north of West Tamar at the mouth of the Tamar River. The study area of Kelso extends from the caravan park in the north to the southern end of Kelso Bay (Figure 1).

The village of Kelso is mostly flat and low lying and there is a significant number of waterfront properties.

FIGURE 1 KELSO STUDY AREA

1.5 Remainder of this report

The remainder of this report describes the findings so far for the Kelso study area. It covers:

- Current day and future coastal risks
- Current relevant planning scheme mechanisms
- Costs of risks in the study area
- Current property values, public benefit and other values in the project site
- Adaptation options with an introduction that explains what is likely to happen if nothing is done to manage current and future risks
- Possible adaptation pathways for the study area

2 COASTAL HAZARDS

Kelso is potentially subject to coastal erosion (periodic or progressive), flooding from the sea, flooding from peak river flows and erosion along the river banks. All these risks can occur under present day condition, but with rising sea levels and more extreme weather (including storm and rainfall) the intensity and frequency of extreme coastal events is expected to increase over time.

This section provides site specific information regarding these coastal processes and relates to Step 1 of the project's coastal adaption pathway process.

The shoreline is fairly flat and wave energy generated from the ocean is low. The beaches at Kelso possess a very wide intertidal zone, high tide beaches with a low to moderate gradient and low-tide beaches that are almost horizontal (UTAS, 2012). The tidal range at Kelso is three to four metres.

2.1 Kelso coastal erosion

Erosion may be due to river flow, tidal movements and storm surges. The foreshores in the study area mostly consist of narrow sandy beaches and enforced foreshores. There is little long shore movement along the coast. The existing protection works suggest erosion issues have occurred in the past along Foreshore Rd especially south of the corner with New Rd to the Jetty.

The Kelso foreshore north of the corner with New Rd is classified as open sandy shore backed by soft sediment plain - potential erosion and shoreline recession vulnerability (Sharples, 2006[1]). The shoreline south of the corner with New Rd is classified as open sandy shores backed by bedrock - potential beach erosion, lesser recession vulnerability. The shoreline within Kelso Bay is classified as muddy shores backed by harder bedrock - limited potential vulnerability to erosion, depending on backshore bedrock type.

Past protection works consist of a low sea wall along Foreshore Rd as shown in the photos (below). Along the foreshore, there are sections where new sand sediment is in front of the sea wall, nearly making the sea wall invisible. More progradation has occurred north of the Foreshore Rd. It shows that at least some of the erosion is periodic or seasonal.

[1] Sharples (2006) "Indicative Mapping of Tasmanian Coastal Vulnerability to Climate Change and Sea Level Rise, 2nd edition", DPIW, Tasmania,


Sandy foreshore


Muddy foreshore


Private protection works

Sea wall

Sea wall with new sediment in front

The sea wall was probably constructed in 1952 during a period of significant erosion from 1946 to 1954. Another episode of erosion occurred from 1969 to 2004 (UTAS, 2012[2]). The sea wall has been vertically exposed to wave action.

A wooden groyne at the mouth of a creek was put in place in the past and north of the groyne local progradation has occurred.

Private past protection works include car and tractor tyres and steel concrete-filled drums that have been used to form a retaining wall at the foreshore in front of the caravan park (UTAS, 2012), possibly exacerbating erosion south of the retaining wall. The works may have been undertaken in the early 1990s.

Kelso beach has unrestricted pedestrian access and vehicle access where not impeded by the sea wall. This may have contributed to past erosion.

Possible short term works to minimise further erosion include (UTAS, 2012):

- Restriction of access

[2] UTAS (2012), J. Inglis & J. Ellison, School of Geography and Environmental Studies, University of Tasmania

- Vegetation management to enhance vegetation margin
- Ramp of boulders to reduce exposure of sea wall to wave action and to accumulate sand
- Groyne further south may improve beach sand retention, and maintenance of existing groyne

2.2 Coastal inundation

Sea water height varies with tides, storms and regional wave effects. The combined effects can lead to extreme storm surges and consequently inundation. The most extreme heights occur with a lower probability. Present day storm sea level heights for different probability/frequency are shown in Table 1 below.

TABLE 1 STORM SEA LEVEL PROBABILITY, PRESENT DAY

Average Return Interval (ARI)[3]	Annual exceedance probability[4]	Sea storm level height* (m AHD[5])
20 year ARI	5%	2.33
50 year ARI	2%	2.38
100 year ARI	1%	2.42
200 year ARI	0.5%	2.45

*Includes 30 cm free board and round up to nearest ten centimetres

Source: M.J. Lacey, J.R. Hunter and R.E. Mount (2012), Coastal Inundation Mapping for Tasmania – Stage 2 Version 1; allowances for round-up and free board (June 2013)

The water height data include a round-up of the estimate to the highest ten centimetres to reflect a reasonable level of accuracy that can be expected for surveyors. The storm surge data also includes a thirty centimetre free board on top of the water heights to identify the flood hazard area.

In addition to storm surge effects, there are local influences such as local wind setup, local wave setup and local wave runup. These local effects have not been allowed for in the modelling since reliable data were not available. These local effects may roughly add between 0.3 and 1.1 metres to water height levels depending on how exposed or sheltered the foreshores are to the sea. Kelso foreshore has limited exposure to wave energy from the sea and local effects are likely at the lower end.

Note that all values are 'best estimates' and subject to inaccuracies:

- Inundation depths may vary from estimates by ±0.2m
- Land levels based on LiDAR (best available mapping surface) may vary by ±0.1m
- Actual floor heights may vary from the estimate by ±0.15m
- These errors may act to offset each other or may add together.

With a present day extreme storm event of a one in 100 year probability (1% AEP) areas at risk of inundation are residential properties along the foreshore just north and south of the creek that mouths into the Tamar and where a wooden groyne is placed (Figure 2). There are 17 properties at some level of present day risk of inundation. Rural-residential properties land inward would also be affected including likely overtopping of Greens Beach Rd and New Rd. A significant part of the foreshore in front of where the caravan park is would also be inundated. The flood height would be over 0.3 metres at most of the rural-residential properties.

[3] The Average Return Interval expresses the likelihood for an event to occur as the average number of times an extreme event would occur in a given timeframe.

[4] The Annual Exceedance Probability is a way to express the likelihood for an extreme event to occur. It refers to the probability of an event occurring in any given year

[5] The Australian Height Datum (AHD) is a geodetic datum for altitude measurement in Australia. In 1971 the mean sea level for 1966-1968 was assigned the value of 0.000m on the Australian Height Datum at thirty tide gauges around the coast of the Australian continent. The resulting datum surface, has been termed the Australian Height Datum (AHD) and was adopted by the National Mapping Council as the datum to which all vertical control for mapping (and other surveying functions) is to be referred (Geoscience Australia)

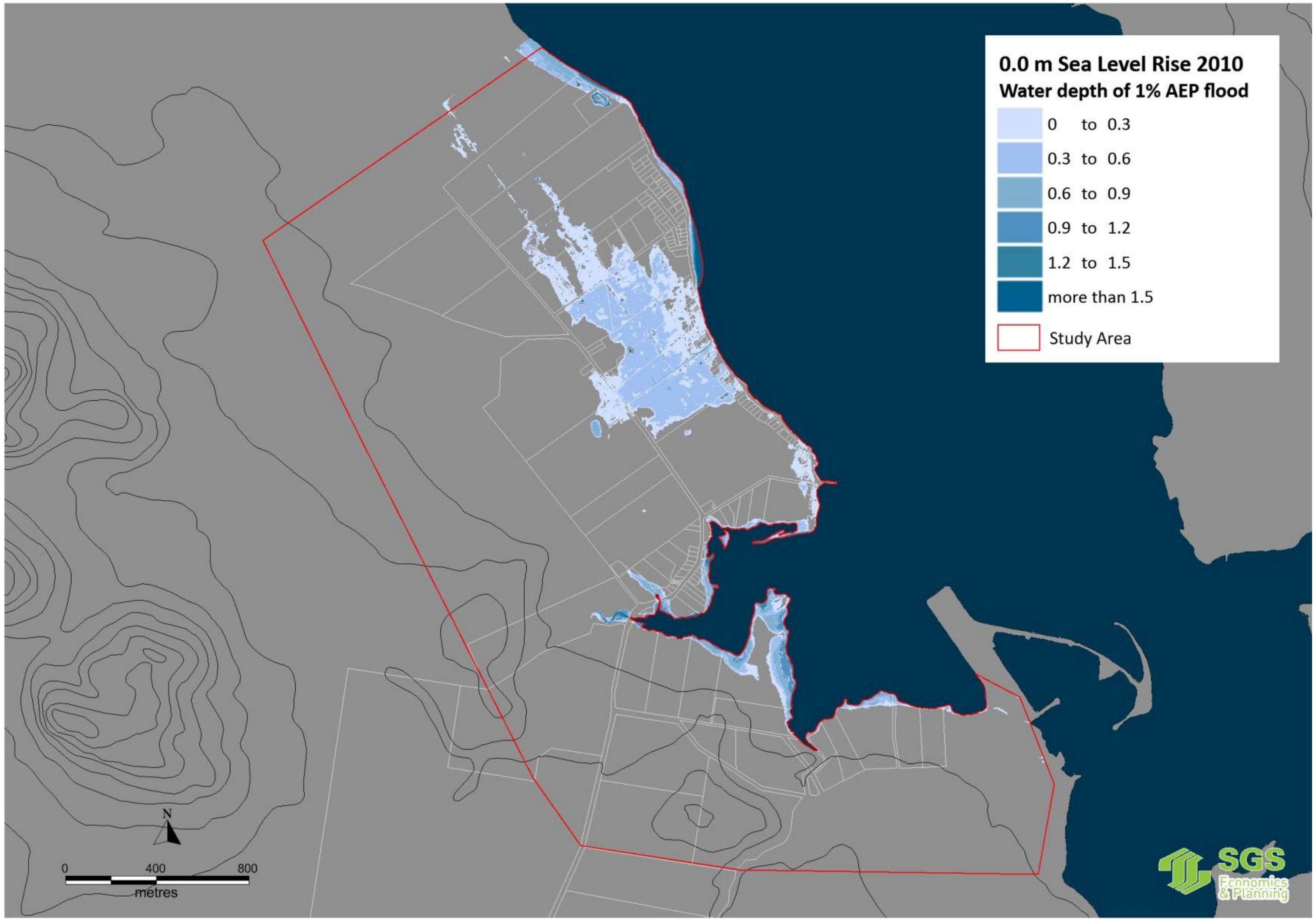
Localised flooding is also expected to occur at residential properties around the jetty, and in Kelso Bay.

Stormwater drainage issues

Extreme storm events and extreme high tides may reduce the drainage capacity of existing drainage infrastructure and creeks.

Anecdotal evidence suggests past extreme rainfall events have led to localised flooding especially in cases of high tides and or storm surge. This flooding is known to have occurred at the crossing of Greens Beach Rd with New Rd and Paranaple Rd to the caravan park.

FIGURE 2 LIKELY INUNDATION AT KELSO FOR AN EXTREME STORM EVENT (1% AEP), PRESENT DAY



Source: SGS (2013) based on M.J. Lacey, J.R. Hunter and R.E. Mount (2012), Coastal Inundation Mapping for Tasmania – Stage 2 Version 1; allowances for round-up and free board (June 2013)

2.3 Coastal hazards with climate change

This section considers expected coastal hazards as a result of climate induced sea level rise of 0.2 metres compared to 2010 levels, which is expected to occur around 2050, and of 0.8 metres, which is expected to occur around 2100.

The hazard assessment does not consider other climate change impacts such as more frequent and more severe extreme weather events and river flooding events.

Coastal erosion

Rising sea levels are likely to contribute to progressive erosion of sandy and soft sediment shorelines. As a rule of thumb, landward erosion for open sandy beaches with breaking waves is between 50 to 200 times the height of sea level rise. This is based on a method known as the Bruun rule. That is, a rise of say 1 metre could lead to erosion of 50 to 200 metres inland. The coastal dynamics behind this rule, which is sometimes contested even for open sandy beaches, does not apply to more protected sandy shores, but observations have suggested the extent in these situations is not dissimilar in practice.

Kelso is both low lying and fairly flat. Such shorelines are particularly vulnerable to erosion (Sharples, 2006).

New erosion modelling and spatial data[6] have been used to identify properties that are susceptible to erosion and the various levels of risk. The hazard bands low, medium and high identify areas of land that are susceptible to erosion:

- Low hazard band: potential shoreline recession to 2100- 61 meters landwards of storm bite hazard zone or to natural recession limit (i.e. 83 meters landwards of High Water Mark (HWM) or to natural recession limit
- Medium hazard band: potential shoreline recession to 2050 – 27 meters landwards of storm bite hazard zone or natural recession limit (i.e. 49 meters landwards of HWM or to natural recession limit)
- High hazard band: potential present day recession. Storm bite and consequent reduced foundation stability zone- 22 meters landwards from HWM or to natural recession limit

The erosion susceptibility mapping takes into account the type of shoreline and the availability of any existing erosion protection works such as sea walls or groynes. It does not consider in detail the quality of these works and how effective they might be to protect against erosion over time.

The map below (Figure 3) displays the potential coastal erosion susceptibility hazard bands for Kelso.

[6] C. Sharples, H. Waldorf & L. Roberts (July 2013) ‘Coastal erosion susceptibility zone mapping for hazard band definition in Tasmania

FIGURE 3 POTENTIAL COASTAL EROSION SUSCEPTIBILITY AT KELSO

Source: SGS (2013), based on C. Sharples, H. Waldorf & L. Roberts 'Coastal erosion susceptibility zone mapping for hazard band definition in Tasmania

The mapping takes into account the potential effects of sea level rise, but does not consider the potential effects of a trend with increasingly more frequent and more severe extreme storm events. Storm events lead to temporarily higher sea levels and wave attack on higher elevations of the beach, resulting in erosion of the beach.

Coastal inundation

Future coastal inundation risks will increase as climate change causes sea levels to rise. The coastal sea level rise mapping undertaken for Tasmania has adopted sea level rise allowances compared to 2010 for 2050 and 2100. Sea levels are projected to rise by 0.2 metres by 2050 and 0.8 metres by 2100. Table 2 below shows the projected water level heights for various types of events in 2010, 2050 and 2100.

While the impact of climate change is now fairly well understood within the scientific community, there is and will remain uncertainty in regards to the pace of climate change and related impacts such as sea level rise. Sea levels may rise slower or faster than projected.

TABLE 2 PROJECTED SEA HEIGHTS, 2010-2100

Annual Exceedance Probability (% AEP)	Present day / 2010	2050	2100
Sea Level Rise (m) compared to 2010	**0.0**	**0.2**	**0.8**
	(m AHD)	(m AHD)	(m AHD)
5%	2.33	2.53	3.13
2%	2.38	2.58	3.18
1%	2.42	2.62	3.22
0.5%	2.54	2.75	3.35

Source: SGS (2013) based on M.J. Lacey, J.R. Hunter and R.E. Mount (2012), Coastal Inundation Mapping for Tasmania – Stage 2 Version 1; allowances for round-up and free board (June 2013)

The estimates are based on the technique of Hunter (2012), observations of storm tides from the tide gauges at Hobart and Burnie, and regional projections of sea-level rise based on the IPCC A1FI emission scenario (Hunter et al., 2012). These allowances were added to the AEPs for 2010, to derive AEPs appropriate to 2050, 2075 and 2100. (Coastal Inundation Mapping Stage 2 V1, TPC, September 2012).

Climate change is also expected to result in more extreme weather events. This could mean that a 1%AEP (one in 100 year) event at present day may become a 5% AEP event by say 2050. The extent to which extreme events become more extreme and more frequent has not been taken into account in the coastal inundation mapping. As indicated earlier, the modelling does not consider local wave and wind conditions due to unavailability of data. The coastal inundation mapping must therefore be interpreted as conservative projections of future inundation hazards.

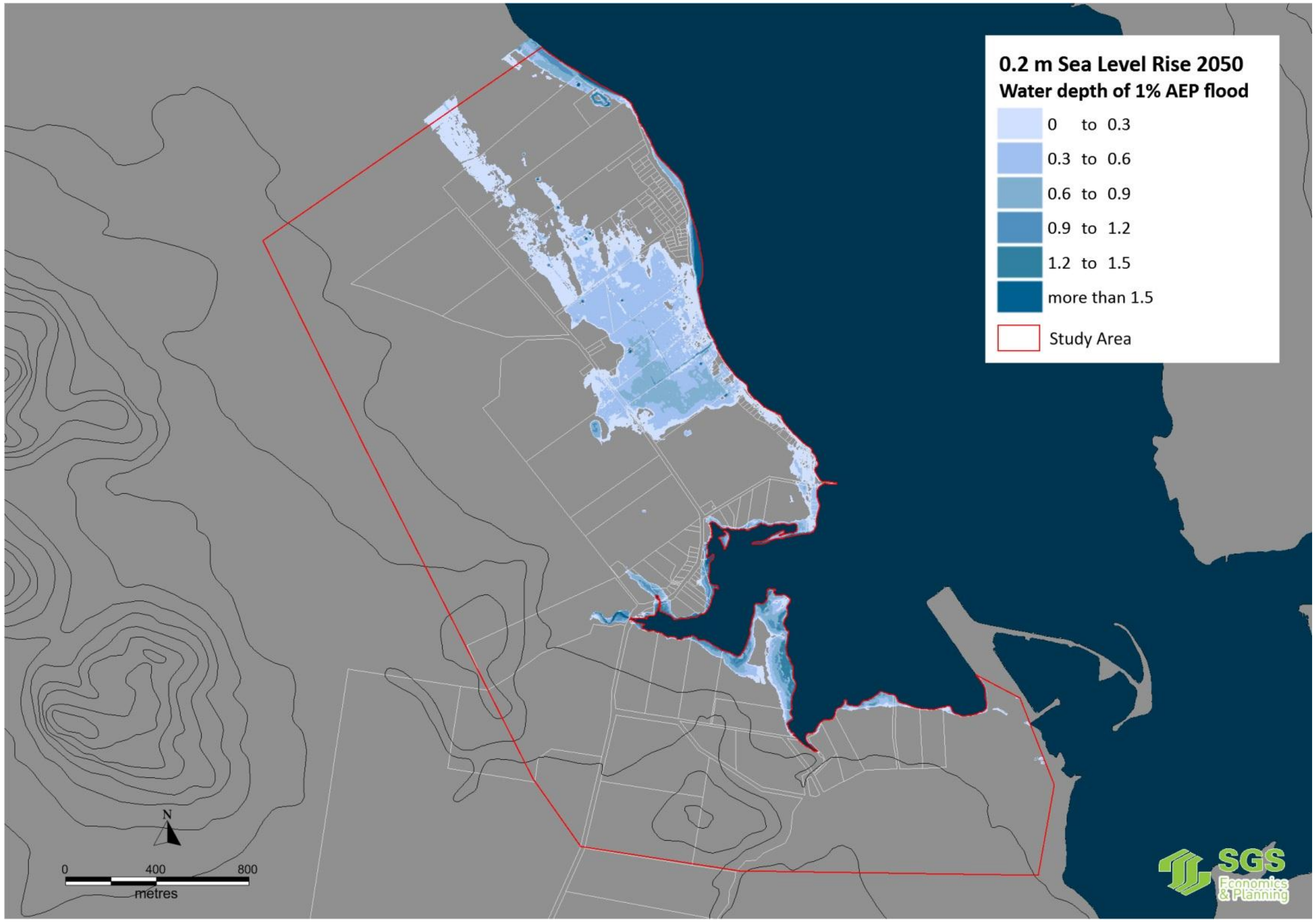
The following maps (Figure 4 and Figure 5) show:

- The area flooded in a 1% AEP event
- The depth of inundation for a 1% AEP event

The maps have been produced using the above referenced coastal inundation data that assumes a sea level rise of 0.2 metres and 0.8 metres. This is projected to occur by 2050 and 2100 respectively. The data includes the earlier referenced round-up to the next nearest ten centimetres and the freeboard allowance of 30 centimetres. The projected rate of sea level rise is approximately 0.5 centimetres per year to 2050, and 1.2 centimetres from 2050 to 2100.

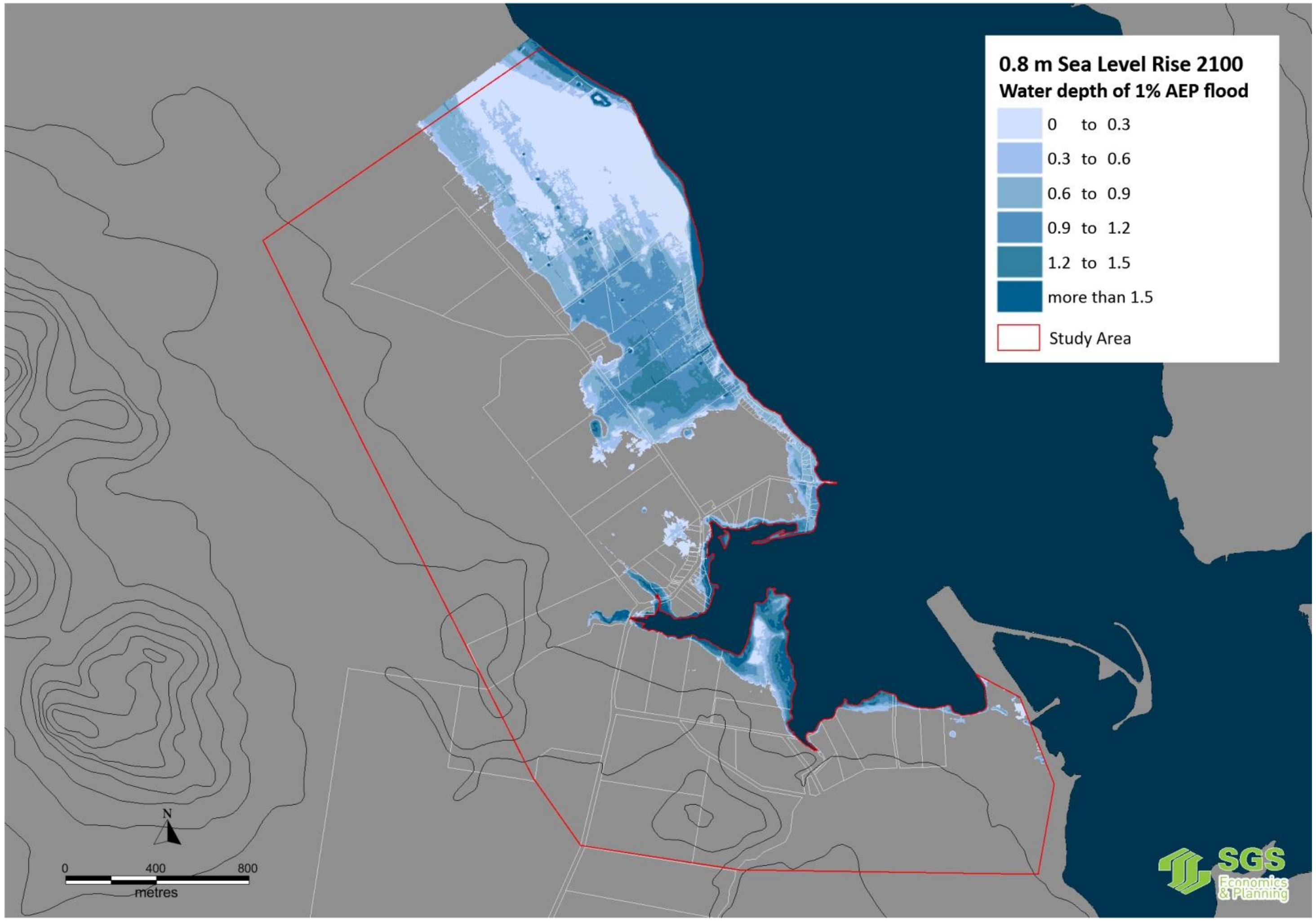
The maps assume that the topography does not change with erosion of the movement of sand from wave action, which is clearly unrealistic. More likely, rising sea levels will cause progressive erosion of sandy shores if no action is taken (previous section). The dynamics of the estuary and mouth will also change. The dynamics of the sediment budget have not been evaluated.

FIGURE 4 LIKELY INUNDATION AT KELSO FOR AN EXTREME STORM EVENT (1% AEP), 0.2 M SEA LEVEL RISE



Source: SGS (2013)

FIGURE 5 LIKELY INUNDATION AT KELSO FOR AN EXTREME STORM EVENT (1% AEP), 0.8 M SEA LEVEL RISE



Source: SGS (2013)

The maps show that a with sea level rise of 0.2 metre (at around 2050) 41 residential properties, of which about 15 with inundation depths of more than 300 mm.

Over time, while the sea level increases, more properties are expected to be at risk from an extreme storm event. An extreme 1% AEP event with a sea level rise of 0.8 metre is likely to affect approximately 97 properties of which 54 with inundation depths of more than 300 mm.

Storm water drainage

Higher sea levels, especially during storm events, may undermine the effectiveness of drainage of storm water (from rainfall and non-coastal flooding) from the area to the Tamar River.

Local wave runup and setup during an extreme event (not considered in the projections) on top of sea level rise and storm surge may exacerbate the impact on the drainage capacity.

The existing storm water drainage issues are likely to become worse, and the duration of such events is likely to increase, if nothing is done to address the storm water drainage issues.

3 PLANNING SCHEME MECHANISMS

This section contributes to **Step 2 of the 15 Step Community Adaptation Pathway: Review of Draft interim planning scheme for coastal hazard areas for West Tamar Council**. The section reviews the existing and proposed West Tamar planning scheme provisions and relevant state and regional directions on coastal hazards and climate change impacts for the Council area.

Section 3.2 reviews relevant state and regional policies, projects or land use frameworks which address the effects of climate change on coastal areas. Section 3.3 reviews the interim draft West Tamar Planning Scheme and details any planning provisions that relate to the mitigation of climate change effects on coastal areas, while section 3.4 briefly looks at the current Planning Scheme as a means of comparison. Section 3.5 provides recommendations for West Tamar Council on planning scheme amendments that could be made prior to detailed scenario planning to better address coastal hazards and climate change risks.

3.1 Regional Planning Initiative

The Regional Planning Initiative covers three regional planning partnership projects: the North West, Northern and Southern region. They have been established through agreements between the State Government, the respective councils and regional bodies. West Tamar Council is located in the Northern region.

Each region has prepared a regional land use strategy and all were declared in October 2011:
- Northern Region: Regional Land Use Strategy of Northern Tasmania
- Southern Region: Southern Tasmania Regional Land Use Strategy 2010-2035
- North West Region: Living on the Coast – The Cradle Coast Regional Land Use Planning Framework

These Strategies or Frameworks are statutory instruments meaning new planning schemes, planning scheme amendments or projects of regional significance must be in accordance with the frameworks. Each Council is now tasked with preparing new planning schemes that will be consistent with the regional land use strategies.

The regional planning initiative is supported by the State Government through Planning Directive 1 – The Format and Structure of Planning Schemes, released by the TPC in May 2011. The directive incorporates a new 'Planning Scheme Template for Tasmania' which Councils use to achieve consistent layout, zones and terminology of planning schemes.

3.2 Regional Land Use Strategy Northern Tasmania

The *Regional Land Use Strategy of Northern Tasmania* was declared on 27 October 2011. The purpose of the strategy is to map out key strategic land use issues that need to be resolved to give some sense of order to priorities rather than to lock in specific strategies as right or wrong. Natural Hazards; Climate Change Adaption; and Coasts, Waterways and Wetlands are addressed in the framework under Part D – Regional Planning Policies.

Clause 4.6.2 Natural Hazards
The framework acknowledges that land use planning has a role in adapting to climate change by mitigating the effects through spatial planning decisions. Hazards identified are: acid sulphate soils, bushfire, contaminated land, flooding, land instability, salinity, sea level rise and storm surge, and soil erosion.

Relevant policies are contained at Clause 4.6.7 Regional Policies and Actions. Policies and actions contained under Natural Hazards that are relevant to the effects of climate change on coastal areas are:

Natural Hazards			
Policy		**Action**	
NH-P01	Ensure that future land use and urban development minimises risk to people and property resulting from land instability by adopting a risk managed based approach consistent with Practice Note Guidelines for Landslide Risk Management 2007 and AGS (2007a) "Guidelines for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning"; AGS (2007e) "Australian GeoGuides for Slope Management and Maintenance".	NH-A01 NH-A02 NH-A03	Manage further development in declared landslip zones. Complete regional land slide hazard mapping to allow the identification of land susceptible to landscape hazards and level of risk associated to specific scale and types of land uses and development. Ensure appropriate land uses and urban development in areas of susceptibility only where risk is very low or that it can be managed by prescriptive controls to avoid undue risk to persons including life or loss and damage to property. If there is doubt about the geotechnical stability of land proposed for urban development, Council may require a geotechnical assessment to identify risks and mitigation techniques.
NH-P02	Ensure that future land use and development minimises risk to people and property resulting from flooding.	NH-A04	Include controls in planning schemes based on current best practice to manage risk to persons and property resulting from inundation.
NH-P06	Where avoidance of hazards is not possible or the level of risk is deemed acceptable, ensure best practice construction and design techniques and management practices are implemented.	NH-A09	Adopt the relevant risk management AS/NZS standard as part of core management methods to emergency, hazard and risk management.

Map 10 of the Strategy identifies the areas where natural hazards are present including flood and landslip. This mapping, however, is not detailed and shown at a scale of 1:750,000 (in A3).

Clause 4.6.3 Climate Change Adaptation
Northern Tasmania is expected to experience higher average temperatures and lower average rainfall. Impacts may include more extreme weather events, hotter and drier summers, warmer winters and increased flooding and rising sea levels leading to coastal realignment and inundation. These potential impacts will affect the following elements of land use and development:

- Infrastructure – including location and design measures to allow adaptation;
- Water – the availability of water is a key issue;
- Transport – change in climate may alter long term performance and durability;
- Energy – demand, reliability and availability will change;
- Biodiversity – many individual species and entire ecosystems are extremely vulnerable to climate change; and
- Land – fire, floods and drought regimes will change.

Relevant policies are contained at Clause 4.6.7 Regional Policies and Actions. Policies and actions contained under Climate Change Adaptation that are relevant to the effects of climate change on coastal areas are:

Climate Change Adaptation		
Policy		**Action**
CCA-P2	Protect investment in new infrastructure from the impacts of climate change.	

Clause 4.6.5 Coasts, Waterways and Wetlands
In Tasmania, planning schemes have historically only included provisions relating to water quality. The Strategy identifies that there are other coastal, waterway and wetland issues which could benefit from a regional approach.

Relevant policies are contained at Clause 4.6.7 Regional Policies and Actions. Policies and actions contained under Coasts and Waterways that are relevant to the effects of climate change on coastal areas are:

Coasts and Waterways		
Policy		**Action**
CW-P03	Minimising or avoiding use or development in areas subject to areas of high coastal hazard.	CW-A04 Planning schemes shall include provisions for land adjoining the coast that: • Restricts development so as to minimise long term risk to life and property and its impact on the coastal process. • Require that the impact of engineering works on coastal processes is adequately assessed against appropriate engineering standards and best practice. CW-A05 Identify those areas at high risk of sea level rise, storm surge inundation and shoreline recession through the use of overlays or zones within Planning Schemes.

3.3 West Tamar Interim Planning Scheme 2013

West Tamar Council has drafted a new planning scheme using the new state planning template to align with the Regional Land Use Strategy of Northern Tasmania.

The West Tamar Interim Planning Scheme 2013 came into effect on 16 October 2013.

Neither the general objectives of the planning scheme nor the natural environment objective encapsulate recognition of coastal vulnerability. The planning scheme's natural environment objective is to "manage change in areas containing native vegetation, ecosystems, waterways and open space to ensure maintenance of biodiversity and enhancement of natural landscape values in the West Tamar Municipal area".

The West Tamar Interim Planning Scheme uses Zone and Code Provisions for addressing coastal vulnerability. The codes are the primary mechanisms for including use and development provisions that address this risk.

Zones

The Environmental Management Zone has been used in this planning scheme to address some aspects of coastal vulnerability.

Four additional zones include development standards for addressing the presence of natural hazards in regards to subdivision applications. These are the Village Zone (Clause 16.4.2), Community Purpose Zone (Clause 17.4.2), Light Industrial Zone (Clause 24.4.2) and the Utilities Zone (Clause 26.4.2). Each of these clauses contain the following performance criteria within its development standards for subdivisions:

Performance Criteria
P1 Subdivision must: a) provide for each lot, sufficient useable area and dimensions to allow for: iv) the presence of any natural hazards.

Due to the broad brush term of 'natural hazards' being used, coastal vulnerability or sea level rise is not mentioned specifically in any zone.

The need to prepare conservation reserve or hazard management plans when undertaking certain activities ensures that hazards need to be considered.

The Codes provide more detailed definitions and requirements in regards to coastal hazards.

Codes

Codes set out standards for use and development for matters that are not confined to one zone and apply over and above zone provisions.

There are four codes which include use and development standards that recognise coastal vulnerability. The codes are the Landslip Code, Flood Prone Areas Code , Water Quality Code and Coastal Code.

The Kelso study area would mostly have to deal with the Coastal Code, and possibly to some extent the Flood Prone Areas Code.

E3.0 Landslip Code

The purpose of the Landslip code is to

a) ensure that use and development subject to risk from land instability is appropriately located and that adequate measures are taken to protect human life and property; and
b) ensure that use and development does not cause, or have the cumulative potential to cause an increased risk of land instability.

Development Standards for the Landslip code provided in Clause 3.6. Where development occurs within a landslip area, performance criteria require the risks be addressed appropriately.

E3.6.2 contains a risk assessment framework to be used when determining the level of risk for developments proposed on land subject to landslip.

E5.0 Flood Prone Areas Code

The purpose of this provision is to:

a) ensure that use or development subject to risk from flooding is appropriately located and that adequate measures are taken to protect human life and property and to prevent adverse effects on the environment.

b) determine the potential impacts of flooding through the assessment of risk in accordance with the Australian Standard.

Use Standards for the Flood Prone Areas Code are contained within E5.5. The standards define acceptable solutions, and if not met, performance criteria require the risks be addressed appropriately.

The scheme contains a risk assessment framework to be used when determining the level of risk for developments proposed on land subject to flooding. This risk assessment framework is detailed in the appendix of this document.

E9.0 Water Quality Code

The purpose of Water Quality Code is to:

a) consider the impacts of development to limit adverse effects on the following:

- i) wetland and watercourse ecosystems; and
- ii) flow regimes, water levels, biological activity and physical characteristics; and
- iii) the variety of flora and fauna; and
- iv) the role of wetlands and watercourses for water supply, flood mitigation, environmental protection, water regulation and nutrient filtering, as resources for recreational activities and as attractive features in the landscape; and

b) improve the sustainable management of surface water through development

Development Standards for the Water Quality Code are contained within E9.6. The standards define acceptable solutions, and if not met, performance criteria require the risks be addressed appropriately.

E14.0 Coastal Code

The purpose of the Coastal Code is to

a. consider the impacts of use and development within the coastal environment
b. limit the risk to human life and the built environment as a result of sea level rise, storm surge, shoreline recession and coastal inundation; and limit the adverse effects of use and development on the coastal environment; and
c. limit the adverse impacts of vegetation removal.

The code applies to use or development of land:

a. on land located at or below the height indicated on the coastal inundation height reference map; or on, within or adjoining the coastal dune system; or
b. on land adjacent to or on landforms defined as vulnerable to erosion or recession in the Indicative Mapping of Tasmanian Coastal Vulnerability to Climate Change and Sea Level Rise: Explanatory Report (Sharples 2006); or
c. on land, even if not mapped, if it is identified in a report prepared by a suitably qualified person in accordance with the development application which is lodged or required in response to a request under Section 54 of the Act as actual or potential landforms vulnerable to erosion or recession.

Use Standards for the Coastal Code are contained within E14.5. The standards define acceptable solutions, and if not met, performance criteria require the risks be addressed appropriately.

Development Standards for the Coastal Code are contained within E14.6. E14.7.1 contains a risk assessment framework to be used when determining the level of risk for developments proposed in coastal areas. This risk assessment framework is detailed in the appendix of this document.

Assessment of Codes

Within the Flood Prone Areas code, there are provisions to ensure that use or development must demonstrate low risk levels to life and property. However the risk assessment framework provided prescribes levels of consequence, ranging from catastrophic loss of life to insignificant. The two frameworks make it unclear what areas are at risk. The Water Quality Code and the Coastal Code both prescribe a metre boundary which excludes development from being permitted (or severely limited) within that boundary. The risk to prescribing a set metre boundary is that the planning scheme cannot respond to climate change variables such as sea level rise. Within the life of this planning scheme, a 30 metre exclusion zone from development around the high water mark may no longer provide an adequate buffer. However the 30 m provision in the coastal code should be considered in combination with the provision on level of risk.

The water quality code includes provisions to ensure that impacts from storm events up to at least the 1 in 5 year storm are not increased. Climate change may lead to 1 in 5 year storms, indeed 1 in 50 year storms being much more frequent than they are in present day. This is a positive step which allows for changing levels of risk over time.

An independent, scientific source (Sharples) is identified to determine the level of risk for an area, which provides a common understanding of risks or hazards that may need to be addressed the risk assessment. Section E. 14.7.1 refers to different risk levels (such as 1% AEP), but does not consider how risks should be considered over the lifetime of the proposed development or use. The Scheme does not warrant that use and development remain within acceptable levels of risk during their lifetime with increasing levels of risk due to climate change (based on the best available evidence about the pace of climate change impacts).

Maps

The planning scheme maps provide indications of zoning changes from the 2006 planning scheme. Planning Scheme maps provide no indication of flood risk, land slip areas or coastal inundation. The Scheme refers to independent, scientific sources to identify risk areas. The introduction to the coastal code refers to the source that should be used to determine hazard areas.

Comparison West Tamar Planning Scheme 2006

When comparing the West Tamar Interim Planning Scheme to the current 2006 document, it is apparent that recognition of coastal vulnerability has markedly increased since the 2006 document was incorporated.

The 2006 Planning Scheme listed the prime objective as aiming to enhance the West Tamar Municipal area as a desirable place to live and visit. Natural Environment Objectives centred on protecting areas containing native vegetation, ecosystems, waterways and open space to ensure maintenance of biodiversity and enhancement of natural landscape values in the area.

Zones

The only Zone that refers to coastal areas is the Coastal Management Zone (Clause 12.0), incidentally a zone not used in the Interim Planning Scheme. However the zone does not incorporate notions of coastal vulnerability in its objectives, or its use and development mechanisms.

Schedules

There are four schedules which identify and plan for elements of coastal vulnerability. These schedules are the Flood and Storm Surge Schedule, Landslip Schedule, Marine and Coastal Development Schedule and Wetlands and Watercourse Schedule. These are provided as an appendix to this document.

Considerations

- Council to identify hazard areas for inundation due to sea level rise and coastal erosion vulnerability based on the most recent versions of any paper pointed to within the planning scheme.
- Overlay maps identifying the expected hazard areas are to be incorporated into the planning scheme where available.
- The Scheme refers to independent scientific sources in regards to identifying hazards. These sources tend to be reviewed and updated every few years, and as a result the planning scheme may need to be amended. The scheme could also include a statement that requires the most current revisions of these sources to be identified as the relevant source to consider in relation to a proposed use or development, thereby preventing the need for an amendment.
- More detailed specification of acceptable levels of risk including how risks may change over time is needed. This should then be related to the lifetime of the type of use or development. For example, the acceptable level of risk may differ between types of uses such as car ports compared to new dwellings and hospitals. The proposed use or development should be designed and built in such a way that it remains within an acceptable level of risk during the asset's lifetime.

A coastal reserve management plan exists for the Kelso area (RD&M 2002b), which has focus on coastal vegetation and weeds, with no geomorphic or erosion control content.

4 COST OF RISK

This section assesses properties at risk of being affected by inundation or sea level rise to 2100. The total risk is expressed in net present value, which is the present day value (in $) of future costs and revenues (cash flows).

This section relates to Step 3 and 4 of the adaptation pathway process.

In reading this section it is important to define the term **risk**. Risk is the result of the **total damage** multiplied by the **probability** of an event happening. While the total damages from an event actually happening can be very substantial, the probability of it happening is often quite low. Therefore, the total risk (in $) may be substantially below the total damages of an extreme event.

The analysis of the cost of risks is presented here only for private properties and only for inundation, not coastal erosion. Infrastructure, public amenities, the golf course and open space also may be damaged by coastal inundation. The same level of information about the cost of damage as a result of flooding is not readily available for infrastructure as it is for dwellings.

4.1 Inundation Risks

While a significant number of properties may be at some level of present day or future risk of inundation, in many instances the flooding is below floor level with limited damage risk. This section focuses on potential flood damages and hence above floor height flood risks.

The key findings about inundation risks in Kelso are summarised below:

- 17 residential dwellings have some present-day inundation risks[7]. Of those, 14 dwellings have less than 1% chance of inundation. The remaining three have inundation probabilities of between 6% and 14%, and are located on Foreshore Road.
- With a sea level rise of 0.2 metres from today's levels (expected by about 2050), there will be 16 additional dwellings at potential inundation risk. The average inundation probability of those at present-day risk is expected to increase significantly from 1.4% (with no sea level rise) to 8.8%.
- With a sea level rise of 0.8 metres from today's levels (expected by about 2100), 97 properties would be at some inundation risk, with average inundation probability of 44%.
- Of these, 50 dwellings in Kelso would be flooded by a 1% AEP (1 in 100 year event) event with an average above-floor depth of 0.45 metres.
- 27 parcels of land would be lost, falling permanently beneath the high tide level (with a sea level rise of 0.8m).

Table 3 below shows the estimated number of properties in Kelso that would be flooded above floor level by a 1% AEP event at present day sea levels, with 0.2 metre sea level rise and with 0.8 metre sea level rise.

[7] Risk, if not specified, refers to more than 0.01% chance of having an over floor flood.

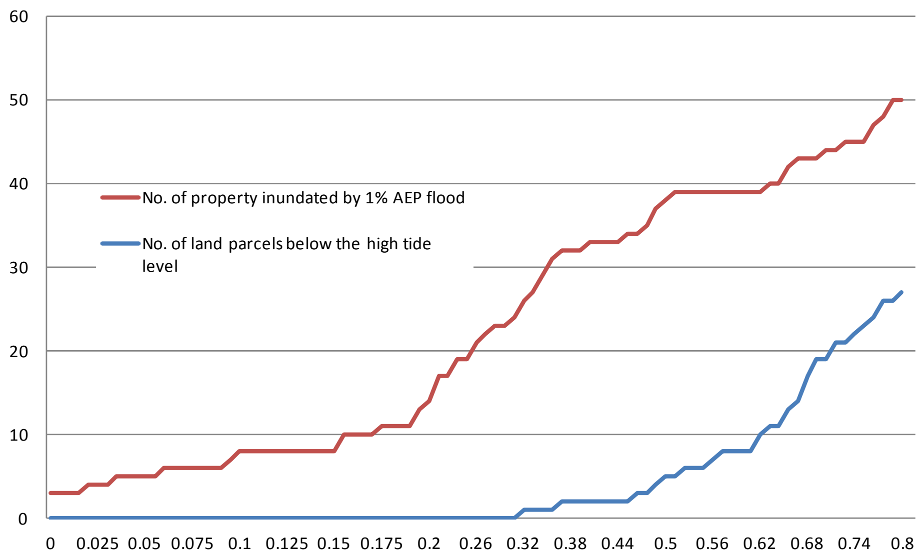
TABLE 3 NUMBER OF INUNDATED PROPERTIES[8] AND AVERAGE OVER-FLOOR DEPTH CAUSED BY 1% AEP FLOOD

		Estimated No. of inundated properties	Average over-floor depth (m)
0.0	**(2010)**	3	0.13
0.2	**(2050)**	14	0.13
0.8	**(2100)**	50	0.45

Source: SGS estimates (2013)

As sea levels rise the number of properties at some risk of flooding increases. With 0.8 metre sea level rise, 50 properties are at risk, **more than one third of the properties** surveyed. This trend is shown in Figure 6.

FIGURE 6 NUMBER OF HOUSES AFFECTED BY 1% AEP FLOOD AND LAND BELOW HIGH TIDE LEVEL, WITH VARIOUS SEA LEVEL RISES, IN KELSO



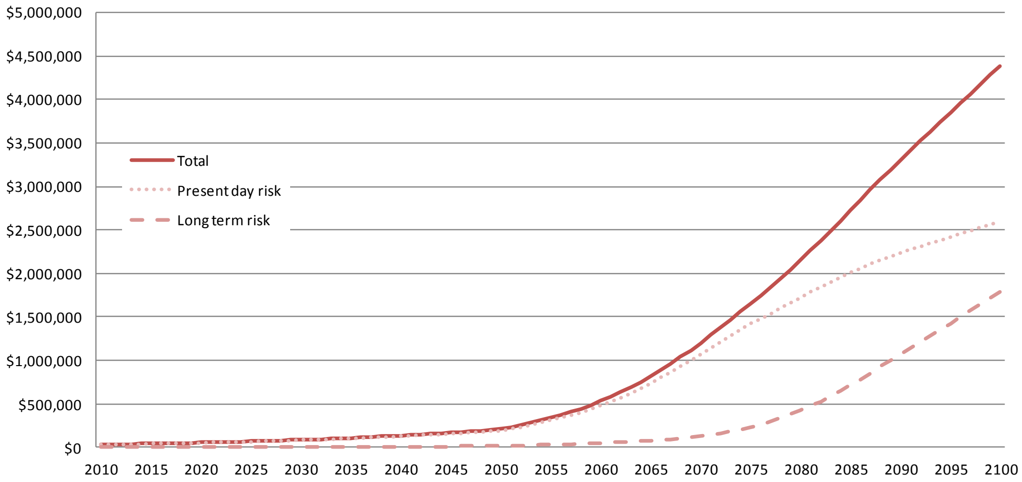
Source: SGS (2013)

4.2 Property Risks

The charts below depict the expected risks (structure damages x probability) in dollar values over time. Expected risk is calculated for each property within the study area for each year by considering likelihood/probability of different flood depths occurring and associated structure damages (derived from the damage curve) as sea levels rise. The total risk at Kelso is a sum of the risk to all properties. The figure below shows the expected risk to structures assuming the properties are fully maintained over time with a minimum level of depreciation in structure value (Figure 7).

[8] Includes residential properties with above floor level inundation depths only

FIGURE 7 EXPECTED ANNUAL STRUCTURE DAMAGES (IN REAL DOLLARS) AT KELSO, WITHOUT DEPRECIATION

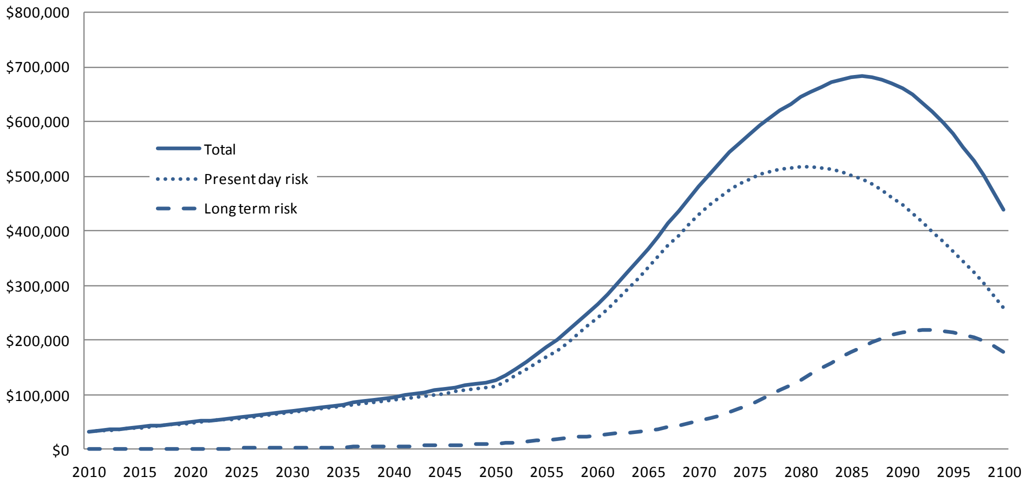


Source: SGS (2013)

The calculations assume that dwellings would be repaired to their previous condition after every flood until the expected annual damage reaches 10% of the replacement value in any one year. At that point the property is dropped from the calculation on the basis that it either would cease to be repaired (too much damage) or it would have been rebuilt in a non-flood vulnerable form (higher floors, flood proof construction).

If the properties are fully maintained and renewed over time, but not expanded or upgraded, with minimum level of depreciation in structure value, the expected structure damages at Kelso start at just over $33,000 in 2010. They grow increasingly rapidly from 2050 onwards, peaking at approximately $683,000 in 2086. (Figure 8).

FIGURE 8 EXPECTED ANNUAL STRUCTURE DAMAGES (IN REAL DOLLARS) AT KELSO, WITH DEPRECIATION



Source: SGS (2013)

The net present values (NPV) of these expected future coastal inundation structure risks are calculated using a real discount rate of 5% per annum and are provided in the table below (Table 4).

Without structure depreciation (i.e. assuming ongoing investment on maintenance and capital upgrade), the NPV of the future risks amounts to $4.3 million.

If the properties in Kelso are assumed to be fully depreciated in 100 years (i.e. not properly maintained and upgraded), the NPV of the structure risks is $2.0 million.

We have classified the residential dwellings[9] in the study area into three categories:

1. The 17 dwellings with present-day inundation risks
2. The 97 dwellings with no present-day inundation risks but at risk with 1 m sea level rise
3. Those not at risk even with 1 m sea level rise.

The table below shows that the total risk to structures at present day risk is high compared to their value.

TABLE 4 NPVS OF TOTAL STRUCTURE DAMAGES[10], AND THEIR SHARE OF THE EXISTING STRUCTURE VALUES

	Present day risk		Long term risk		All
Current value and count	**$4,145,000**	**17 dwellings**	**$19,440,000**	**97 dwellings**	**132**
	NPV of expected damages	**% of existing capital value**	**NPV of expected damages**	**% of existing capital value**	**NPV of expected damages**
Without structure depreciation	$3,610,000	87%	$665,000	3.4%	$4,270,000
With structure depreciation	$1,830,000	44%	$200,000	1.0%	$2,030,000

Source: SGS estimates (2013)

The expected risk is significant in today's net present value terms, but the damage of an extreme storm event if it actually does occur would be much higher. Table 5 below shows that the potential damage caused by an extreme storm with a 1% annual probability could result in a total damage of around $6.1 million in 2100 if the dwellings are well maintained.

TABLE 5 TOTAL DAMAGES CAUSED BY 1% PROBABILITY FLOOD

	Total damages caused by 1% AEP (100 yr ARI) flood		
	2010	**2050**	**2100**
Without structure depreciation	$125,000	$1,130,000	$6,130,000
With structure depreciation	$125,000	$675,000	$615,000

Source: SGS estimates (2013)

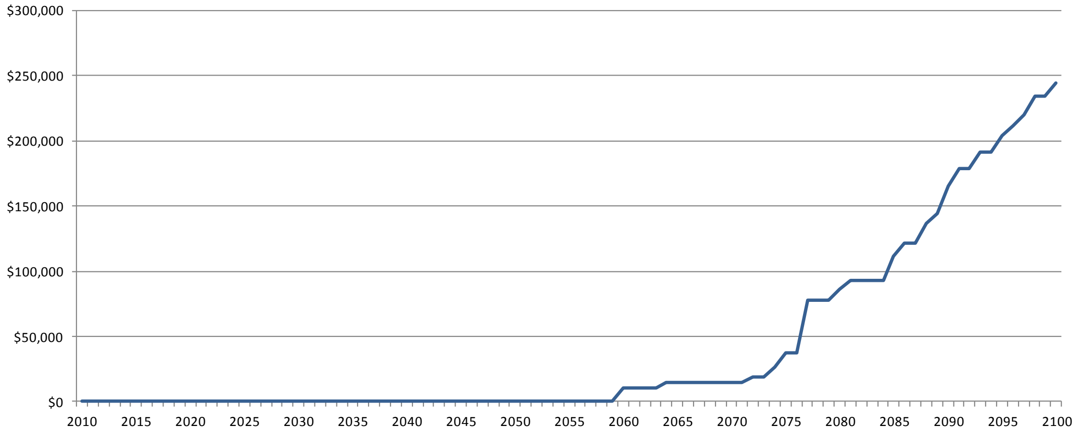
These flood estimates are based on the effects of sea level rise on coastal inundation (from the sea). These estimates do not include cost of damage:

[9] Includes residential properties with any depths of inundation (also below floor level flood depth)
[10] Amounts rounded to the nearest $5,000

- To public infrastructure (roads, street lighting, water supply, damage to the sea wall, and other public amenities)
- From erosion
- To other commercial infrastructure (telephone, electricity supply)
- From river flooding events for all assets, which may be as large as flooding from the sea.

In addition to the structure damages as a result of the over-floor flood, we have estimated the value (per West Tamar Council) of land lost once it is lower than the average high tide level (Figure 9).

FIGURE 9 EXPECTED LAND LOSS AT KELSO



Source: SGS (2013)

If nothing is done, the area of residential land in Kelso will start to diminish from 2060. By 2100 the total land loss is expected to reach 27 parcels with a value of $244,000 based on present day valuation. The NPV of these losses is estimated to be around $7500.

Comparison with acceptable levels of risk with no sea level rise

For risks that do not change over time, potential damage from events with an annual probability at or below 1% is often considered an **acceptable level of risk**[11]. A property that has a floor just at the 1% AEP flood level has an expected damage in any given year of 1.1% of the value of the structure[12]. On a structure worth $100,000 this corresponds to an expected annual damage of about $1130 if exposed to this level of risk from inundation from the sea in Kelso.

Without sea level rise this value would remain the same each year. The lifetime NPV of risk would increase with the expected life of the structure to almost 23.5% of the structure value in the Kelso area. If it is assumed that the building depreciates over time, the value lost from a major flood would be less. The economic loss is only that of the depreciated value of the dwelling.

With sea level rise (about 0.8 m over the next 90 years) the risk of damaging floods increases every year. The risk rises particularly quickly in later years as the rate of sea level rise increases and many more flood events are expected to be damaging. In that case, the NPV rises continuously to 2052, after which

[11] Different acceptable levels of risk would be applied to different uses. A much lower level of risk would be used for a school or hospital compared to a boat shed or car port.

[12] It is normal to require a freeboard above the predicted flood level, usually of about 0.3 m. The expected damage for such a building could be even less, but the freeboard is often used to compensate for uncertainties in the estimate of actual flood levels.

buildings at risk of flooding are assumed to have been abandoned or rebuilt in flood-proof form. The lifetime NPV reaches about 37.6% of the structure value[13] in the Kelso area.

For many properties, the risks can be reduced to an acceptable level by increasing the floor level. For instance, for structures with an expected lifetime of less than 60 years, the required increase in floor height above the present day 1% AEP level is very modest, less than 0.2m.

For dwellings with floor levels above the current 1% AEP flood level, risks for the first few decades are significantly lower than for those at the 1% AEP level. After that time, risks increase significantly and it may be wise to protect the structures or alternatively to not reinvest in the property, depending on the remaining life expectancies.

Conclusion

The estimated cost of risk (in present day values) of coastal inundation to private dwellings is between approximately **$2.0 million and $4.3 million to 2100** depending on whether owners continue to maintain their dwellings.

By 2100, an extreme storm event (1% AEP) is estimated to cause $6.1 million worth of damage (without structure depreciation) if the existing buildings or comparable ones are still in their current locations and elevations.

In addition, some land parcels at present-day inundation risks would become permanently inundated if no protection work is undertaken to cope with the future coastal hazards. With a 1 m sea level rise (likely post 2100), 27 land parcels in the study area are likely to be lost, resulting in a total loss of $244,000 (current day value).

The flood estimates are based on the effects of sea level rise on coastal inundation (from the sea) and ignore rainfall runoff floods from the river, which may be more frequent and more severe than coastal flooding. The extent of the river flooding has not been quantified.

In practical terms:

- Well maintained high quality buildings close to or below the 1% AEP flood level with a long expected lifetime would be well advised to invest[14] in flood protection measures such as flood skirts that can be deployed when required **and** to pay attention to extreme weather forecasts.
- The owners of buildings close to or below the 1% AEP flood level that are in poor to modest condition or buildings damaged by flood events should consider whether it is worth reinvesting in the existing building or demolishing and rebuilding at a level above the flood or in a form that is resistant to flood damage.
- All occupants in hazard areas with properties at some risk, even if only for extreme events with a probability below 1% AEP, should have and rehearse an emergency response plan.
- Governments have an interest in prohibiting redevelopment that will be affected by a higher than acceptable risk of damage during its lifetime, including discouragement of reinvestment in existing properties that are or will be at higher than acceptable risk over their lifetime. However, such risks can be addressed by raising dwellings by relatively modest amounts even for quite long lifetimes.

[13] For properties with a life expectancy of maximum 100 years

[14] Up to20% of the structure's depreciated value assuming a 50 yr lifetime. Less if shorter lifetime expected.

5 COASTAL VALUES

People occupy and use areas near the coast, some of which are exposed to coastal hazards, because they derive value from doing so. Coastal property values are typically higher than similar sized properties inland, showing the premium placed on these areas. Other public, natural and economic values are major contributors of value from the ‘use’ of the coasts.

If the planning response to sea level rise prevents all (re)development in areas potentially at risk, many of the values from using and occupying these areas would be foregone, while other natural values may or may not gain from excluding development.

This section describes the private property values and other values of the study area.

The reporting in this section relates to the work undertaken and the findings so far in relation to Step 5 of the adaptation pathway process: assess the value of occupation or use of the coastal hazard area.

5.1 Private property and assets at risk

Residents in coastal areas derive a private property benefit from living in these areas. In order to assess the potential impacts of climate change and adaptation measures on coastal properties, one needs to understand how significant the premium is for living there.

The total value of all properties in the study area is $26 million. The study area comprises 132 residential properties, some of which are at risk from coastal hazards at present day. The average value of a property is $195,000.

Residential properties at risk of inundation

The previous section discussed in detail how properties in the study area are at risk of inundation with sea level rise. To 2100 there are likely to be 97 residential properties that will be at some risk of inundation. The total estimated value of these properties is approximately $ 19 million.

Properties at risk of erosion

Based on the coastal erosion susceptibility data by Sharples et al it is possible to identify what properties may be at risk of erosion at present day, by 2050 with an expected sea level rise of 0.2 metre and by 2100 with an expected sea level rise of 0.8 metre.

Those properties of which the **majority** of land area is within a hazard band have been identified as susceptible to erosion[15]. In total there are 77 residential properties identified as susceptible to erosion:

- It shows that in total 45 residential properties are within the **low hazard** band. These properties are mostly along the Foreshore Rd and some along Kelso Jetty Rd and Greens Beach Rd. These properties are potentially at risk of erosion by 2100.

[15] The number of parcels of which less than half is at risk of erosion is much higher.

- There are 32 residential properties identified within the **medium hazard** band. Most properties are along the Foreshore Rd with a concentration of properties from 109 to 143 Foreshore Rd. These properties are potentially at risk of erosion by 2050.
- There are no properties that lie within the high hazard band.

Although no property was classified as being at high risk of erosion, it should be noted there are several properties of which part of the land is within the high hazard band.

The total value of the 32 residential, developed properties[16] being classified as medium is approximately $ 7 million or an average capital value of $215,000 per property. The average land value is approximately $9,000[17].

The total value of the 45 residential, developed properties being classified as low risk is approximately $ 4 million or an average capital value of $207,000 per property. The average land value for these properties is approximately $8,000[18].

The total value of all residential, developed properties in the study area is $26 million or an average capital value of $195,000 per property. The average land value for these properties is $8,000.

Generally speaking, those properties closest to the coast are more susceptible to erosion. Assuming other things being equal, the average capital value of properties closest to the beach is $8,000 above the average value of properties that are second closest to the beach. The difference is about $20,000 compared to all properties in the study area (approximately 146 properties).

This suggests that on average people are willing to pay a reasonable premium to own a beachfront property.

Infrastructure and other assets

The section of Foreshore Rd north of the corner with New Rd is within the high hazard band. The foreshore in this area has progaded in the recent past and is currently in a fairly good condition. The projections suggest nevertheless that the road here is at current day risk from erosion.

The majority of the Foreshore Rd south from where the sea wall ends to the corner with Kelso Jetty Rd is within the medium hazard band. The jetty and a small section of Greens Beach Rd are also within the medium hazard band.

At various locations along the foreshore power poles are on the riverside from the road, with these poles often being within the high hazard band.

The Kelso fire station and Telstra exchange are both within the medium to low hazard bands.

5.2 Other values at risk

Other values at risk are the beaches and semi-rural land between Foreshore Rd and Greens Beach Rd.

The study area offers a range of recreational values, including enjoyment of natural values, swimming, fishing, walking and boating. There is one public jetty.

[16] Excluding vacant residential land, businesses, youth camp and caravan park
[17] This appears very low, but the most recent data provided by Council
[18] This appears very low, but the most recent data provided by Council

Tourism is an important economic activity in the area. Potential loss of beaches due to possible protection works would likely to adversely affect some of the natural, recreational and economic values of the area. The caravan park offers the opportunity for many households to spend holidays in Kelso. Access to the caravan park and flooding of the caravan park would adversely impact on the economic activity in Kelso.

Threatened fauna and flora

Threatened species data from the Natural Values Atlas identify the presence of threatened species in the study area (2009, Threatened Fauna Observations). The semi-rural area between the Foreshore Rd and Greens Beach Rd is identified as a habitat area for both the Tasmanian devil and the spotted tailed quoll.

Other species with a conservation value (non-threatened) is the swamp rat which has been observed in the muddy foreshores in Kelso Bay.

With sea level rise, some areas may develop into wetlands or mudflats.

5.3 Conclusions

Properties in the Kelso study area have significant value premiums due to their access and proximity to the beach and the waterfront.

To 2100, 97 properties would be at some level of risk from inundation due to sea level rise and extreme storm events. To 2100, there are in total 77 properties at some risk of erosion due to sea level rise and storm events.
Many of these properties have direct beach or river front access or are located close to the beach. The premiums of properties close to the waterfront are between $8,000 and $20,000 per property.

Refusing any (re)development in the area potentially affected by sea level rise and extreme storms by 2100 could result in significant property value being lost over time.

The natural and environmental values of the Kelso area include beaches, flora and fauna. Sea level rise may result in the development of wetlands.

Social and economic values in the study area involve waterfront related recreation and amenity, recreational fishing and river amenity.

Potential loss of beaches due to possible protection works would be likely to adversely affect some of the natural, recreational and economic values of the area.

6 ADAPTATION OPTIONS

6.1 What if nothing is done?

What would happen if nothing is done? That is, what would the impacts be if nature takes its course and no measures are undertaken to manage the risks?

Inundation (from north to south)

The northern end of the study area is little affected by present storm surges. A part of the caravan park would be affected by a 1% AEP storm with inundation heights between 0.0 and 0.3 metres. An extreme event will likely affect the access road to the caravan park. The foreshore area of the Caravan Park and adjacent foreshore properties could experience flood depths of up to 0.6 metres in the case of such an event. With 0.2 m sea level rise, expected at around 2050, the access road would be more affected over a wider road section by a 1% AEP event. Foreshore flooding would worsen. With a sea level rise of 0.8 m, expected at around 2100, the area of the caravan park where the camping places are will be at risk of inundation with flood depths to 0.3 and 0.6 m.

Current day flood risks from a 1% AEP event affect the residential foreshore south of the protection works, and low lying land between Greens Beach Rd and Foreshore Rd. The Foreshore Rd and the existing protection works act as a buffer to the properties behind the road. Flood depths along the Foreshore Rd will likely be limited to 0.3 metres depth while the semi-rural area between Greens Beach Rd and Foreshore Rd is likely to see depths to 0.6 metres.

Over time, with sea level rising, flooding from a 1% AEP event would largely be restricted to the same area by 2050, with increased depths of inundation. After 2050, with sea level rise expected to reach 0.8m by 2100, the land area at risk of inundation increases significant, putting the majority of the Kelso town at risk from inundation of extreme events (1% AEP).

New Rd and Greens Beach Rd are at current day risk of inundation from a 1% AEP extreme storm event. The roads will likely experience flood depths of up to 0.3m. With sea level rise, flood depths will increase to about 0.6 m by 2050. By 2100 over road flood depths may increase to 1.2 m in case of an extreme 1% AEP storm event.

Drainage issues will likely worsen, as higher water levels may also increase water tables and also reduce the capacity of drainage systems to work effectively during episodes of extreme high tides and storm surge.

The area north and south of the jetty is at current day risk of flooding in case of an extreme event (1% AEP) with flood depths of up to 0.3 m. With sea level rise of 0.2 m, more residential properties will be at risk and flood depths may increase to 0.6 m. With a sea level rise of 0.8 m, an extreme event is expected to flood properties up to 1.2 m.

Many properties at Kelso Bay are at risk from flooding as a result of a present day extreme event. For many properties, only the lower sections are at risk, whereas most built structures are at elevated parts and not currently at risk, with a few properties excepted.

Erosion (from north to south)

Along significant parts of the foreshore, erosion is likely to go hand in hand with increased risks of inundation. Without any measures to address the risks, the effects of erosion, sea level rise and storm surge may reinforce each other.

About 32 properties along the foreshore are likely to be at risk from erosion by 2050. Erosion risks are most significant south of the groyne from 109 to 143 Foreshore Rd.

Parts of the waterfront have been protected by a sea wall, a groyne and unengineered solutions, but eventually higher seas will undermine these with waves that overtop them. Without improved protection the road and eventually the houses behind it will be at risk.

Erosion along the foreshore may be exacerbated by the flow of the Tamar River, thereby affecting the river banks at an accelerated pace.

If nothing is done to manage the developing risks of erosion, dwellings along Foreshore Rd and along Kelso Bay may be eroded away in the long term.

6.2 Options

This section reports on the work undertaken and preliminary findings relating to Step 6 of the pathway process: First cut assessment of adaptation options and costs. The options presented here have not been subject to a technical assessment on effectiveness and costs in the particular situation. A detailed technical assessment of options will be required prior to making any decisions.

There are many different options to adapt to the coastal impacts of climate change. The different options relate to different types of impacts resulting from erosion and inundation. The effectiveness of options varies considerably depending on characteristics of the coastal areas (such as sandy or rocky coast line) and the location-specific impacts of sea level rise.

In the case of Kelso, identified options that are potentially relevant to the impacts are:

- Groynes, breakwaters and structures to reduce erosion
- Construction of a hard revetment or sea wall
- Protecting properties prone to inundation with a levee
- Protecting individual structures
- Floodways/retention basins and improved management of rainfall runoff
- Redevelopment of structures in less vulnerable form (higher floor levels)
- Raising low lying residential areas, roads and services for long term occupation
- Retreat.

Detailed descriptions of the following options are provided in the Interim Local Area report. Short descriptions are provided below.

Groynes, reefs and structures to reduce erosion

Groynes and offshore reefs are mostly applied to high value frontages influenced by strong longshore processes (wave induced or tidal currents) where nourishment or recycling are undertaken.

Groynes are best applied to shingle beaches or within estuaries. Groynes are especially applicable to exposed shorelines with a natural shingle upper beach. Groynes can also be useful in estuaries to deflect flows. The structure life for rock groynes is significant.

Groynes are applicable in combination with beach nourishment or shingle recharging/recycling. Groynes encourage upper beach stability and reduce maintenance commitment for recycling or nourishment.

Groynes may disrupt natural processes and public access along upper beach. It is likely to cause down drift erosion if the beach is not managed.

The cost for groynes is typically between $200,000 and $500,000 per structure, plus recycling (various sources, 2013[19]).

Sea wall or revetments

A sea wall is a massive structure that is designed primarily to resist wave action along high value coastal property. A revetment is a facing of erosion resistant material, such as stone or concrete that is built to protect a scarp, embankment, or other shoreline feature against erosion. Revetments are used to increase the stability of eroding foreshores. As noted, there are already sections of the coast where vertical concrete walls have been placed. The wall was built in 1952.

A properly designed and constructed sea wall can reduce the risks to properties and areas of the foreshore from the impacts of beach erosion and coastline recession hazards. Essentially, the structure withstands erosive forces of waves and prevents further loss of sediment from behind the structure.

They may be located at the top of the shore, out of reach of the water at low tide. Sometimes they may be partly or even fully covered with sediment if there has been a period of accumulation since the wall was built. This may also be assisted vegetation management and access restriction.

Revetments can sustain considerable damage without totally failing, but take up more foreshore space than more vertical sea walls. Rock revetments can be suitable for high wave energy environments, but the potential for scouring in the upper reaches should be considered carefully. Revetments may provide more opportunities to create habitat for marine and coastal wildlife and vegetation than vertical sea walls. They cause less wave reflection than sea walls and survive storms for longer, but generally require regular maintenance to keep their general structural integrity.

Very high water levels will cause waves to overtop a revetment or sea wall. Having significant water flow or trapped water behind the sea wall may cause drainage problems or water logging resulting in erosion and structural instability. With sea level rise, sea walls will need to be periodically increased in height. Revetments of large rocks may need maintenance after heavy storms. It will be possible to extend an existing sea wall if the foundations and sound are capable of withstanding additional loads. Otherwise, the existing wall will need to be demolished and a new larger structure built.

As noted with other coastal structures, sea walls and revetments ultimately restrict sediment transport and may have impacts further along the foreshore. A particular problem with these hard structures can be terminal scouring at the end point. This can be minimised if they continue along a soft foreshore all the way along to a rocky shoreline.

A disadvantage of sea walls, revetments and levees is that they may prevent rainwater from draining as freely, and the drainage system may need adequate retention capacity or pumping to assist during peak storm events where local rainfall is also significant. A high levee can also block views and affect access to properties. A levee that is insufficiently high may fail if the storm surge overtops it and causes a breach, losing much of the protective value expected.

[19] Clarence City Council, Old Bar Council, Scottish Natural Heritage (2013), http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.12.shtml

The costs of sea walls and revetments vary significantly according to local conditions. Sea walls may cost up to roughly $2,000 to $6,000 per linear metre[20].

Protecting properties prone to inundation with a levee

While a few properties are at risk of inundation from a current extreme event, future extreme events will affect more properties, due to sea level rise. Such events occur infrequently and the peak water level usually lasts for only a few hours. However, river flooding events may last longer, up to several days. Levee banks can provide protection against such flood peaks.

A levee could be raised along the foreshore. Such a levee would likely have to be lengthy, extending around the entire residential community to avoid flood waters coming in from adjacent low lying areas.

Such a levee could be applicable once a significant number of properties become subject to flood risks from 1% AEP events, likely between 2050 and 2100.

The costs of levees vary significantly according to local conditions and the height of the levee. The costs of improving and maintaining levees can be substantial.

Some estimates indicate $4,200 - $8,400 per linear metre. A more detailed guideline for construction cost is $1.46 (AUD) million per meter height per kilometre length (Vafeidis et al., 2008).

Protection of Individual Properties

Protecting individual properties from erosion and inundation can be done in different ways:

- Flood barriers to protect existing dwellings from short term extreme events (not practical if water levels are permanently high)
- Piles or massive foundations to resist loss of foundation stability by erosion
- Elevated substructures (raised slab or floor, poles, non-inhabited ground floor) above flood levels
- Moveable dwellings
- Water proof or resistant construction not affected by temporary flooding
- Floatable dwellings.

Flood barriers are either placed directly against a structured wall or free standing barrier, and can be used to protect existing dwellings. Most of the other options apply for new construction but could be used on extensions or where a building undergoes extensive renovation.

Floodways/retention basins and improved management of rainfall runoff

The function of retention basins is to provide temporary storage of stormwater runoff at or near the initial point of flooding. This technique reduces the amount of flooding during large rainfall surges and following the surge, water is slowly redistributed into the drainage system or naturally into the soil.

While designed to address rainfall and runoff, not direct flooding from the sea, in coastal areas subject to rising coastal water levels, stormwater drainage may become less effective where the ends of pipes are submerged below sea level. High storm surge levels from the sea may even enter stormwater pipes and cause flooding by eliminating opportunities for rainwater to drain. Retention basins may accommodate some portion of the runoff and reduce peak flood levels.

[20] Various sources: GCC, 2013: ~$2,000. Sutanto, David et al, 3si: $1,400 to $8,500 .) Mulshone, O., nj.com, 2013: $6,000 and Fraser Coast Regional Council, 2013: $3,100 - $5,800

Basins can lower the peak volumes of water throughout a drainage system, when integrated with the rest of a storm water system. These basins are designed to be one facet of an integrated water system and would not be used in isolation. Complimentary measures could include stormwater outlet fittings that prevent entry of sea water into the storm water drainage system.

Retention basins require a relatively large area in a suitable point in the drainage pattern. It may be difficult to find such a site or be relatively costly land if near a town centre or similar. Alternatively, the retention basin may be useable as an open space or amenity for the community. Such dual use may affect the effectiveness of the basin.

Raising low lying residential areas, roads and services for long term occupation

Raising the land level of developed low lying land, either with existing development or land planned for development, above the expected sea storm surge level is one of the most secure and sustainable responses to rising sea levels. Raising land also reduces the risks to structures and roads of high water tables that can reduce load bearing capacity and, if salty, affect services and structural integrity.

Typically the edge of the raised land would need some protection from erosion. For any new development, or major re-development in inundation hazard affected areas, raising could be a requirement controlled by the planning scheme. Roads and services for the affected area would also have to be raised.

While raising land above the storm surge height can avoid inundation, it represents an obliteration of the existing flora and fauna in the filled area and may also have significant impacts at the source of the fill material.

If the filling is done in stages there may be issues where filled land could increase the flooding of adjacent unfilled land. Such a patchwork filling approach may create problems with drainage unless some considerable thought and planning is put in place to anticipate and manage this issue. An overall filling and drainage plan would be required to avoid the worst foreseeable problems.

Planned Retreat

Progressive retreat means the loss of private and other property. In spite of this, it may prove to be the lowest cost long term alternative available, especially if the cumulative cost of protection into the future is high (higher than the enjoyed benefits or values). This is more likely to be the case if the rate of sea level rise is high and even adapted assets have a relatively short lifetime before becoming under threat.

The cost of planned retreat can be diminished to the cost of land if a process of planned disinvestment occurs, such as not redeveloping and/or extending existing properties.

7 ADAPTATION PATHWAYS

In preparation to the Council and community consultation in November 2013, the following three adaptation pathways have been developed to explore the future for Kelso. Often adaptation is interpreted as retreat or protect. Also, adaptation may be seen as a one-off task with the result being 'we have adapted'.

Adaptation however is a long term process that can follow various pathways. The pathways consist of various adaptation options that are mutually reinforcing and/or complementary to each other, and implemented as required over time. Some adaptation options may be implemented simultaneously, while other options may be implemented sequentially.

For Kelso three main pathways were identified in preparation to the consultation:

1. **Let nature take its course and retreat early.** This pathway allows maximum freedom for natural coastal processes to unfold, with a minimum of intervention or resistance from future development or coastal and flood protection works. Where erosion threatens structures, they would be removed. Where property is regularly inundated, it would eventually not be worth repairing and redevelopment in affected areas would not be permitted.

2. **Protect existing development as long as practical while protecting natural values.** This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community. There is balance between protecting natural and shared community assets, and private property. There is also consideration of promoting and sustaining natural ecosystems in the face of climate change. In general, intensification of development in hazard areas would be discouraged unless it and the protection measures required clearly did not have any negative impact on natural and community values or were likely to have a positive effect.

3. **Protect existing development and permit new development to the maximum possible extent for as long as possible.** This pathway concentrates on protecting the existing and future community and property using any available options. Intensification of development provides more contributors to any protection works, so some intensification is permitted where it does not compromise community values for the suburb. While natural areas may be affected, they may adapt in their own way or become modified in ways that the community accepts.

The pathways are not predictions or recommendations, but ways of imagining different futures based on a range of choices about how to respond to climate change effects. Other variations are possible. All pathways are based on two principles:

- developing risk will be actively managed;
- people cannot be subsidised to occupy or use hazardous locations.

This means firstly that properties and assets must be managed in a way that they are exposed to acceptable levels of risk over the asset's lifetime. For dwellings, infrastructure and services, it is generally accepted that these must be built and designed to withstand a once in a hundred year extreme (1% AEP) event.

Secondly, this means that those who benefit from adaptation works should also contribute to the costs in an equitable way. It also means that those who pay should have a say about adaptation options and pathways.

With climate change, it will be unsustainable to continue to subsidise people who choose to occupy or use hazardous locations in the medium to short term with hazards projected to increase in many ways in all parts of the country. Arguably, current property owners were not fully aware of the potential risks at the time they invested in the area, and some short term works may be provided to enable property owners, residents and operators to consider their future plans.

7.1 Pathway 1 Let nature take its course and retreat early

This pathway allows maximum freedom for natural coastal processes to unfold with a minimum of intervention or resistance from development or erosion and flood protection works. Where erosion or severe flooding threatens structures with failure in the short term, they would be removed if they cannot resist the hazard. Where property is regularly inundated, it would eventually not be worth repairing and be abandoned. Redevelopment in affected areas would not be permitted. Little if any new development would be allowed in hazard areas, and certainly no intensification of existing areas (subdividing existing residential blocks or intensifying rural residential areas).

Property owners would be allowed to take action that extends the life of their existing structures by making it resistant to erosion or flooding (flood skirts, other waterproofing, underpin foundations), but only within their own property boundary, as long as it has no impact on adjacent areas. It would generally not be allowed to fill and raise land, to harden shorelines with rocks or concrete or even to undertake dune or beach nourishment.

How might things be with this pathway?

With nature taking its course, erosion along Kelso's foreshores is expected to proceed, with some cycles of rebuilding but a long term recession of perhaps 23 to 49 metres from the current High Water Mark by 2050 and 50 to 83 metres by 2100. About 32 residential properties might be at risk of loss by erosion from an extreme storm by 2050, currently valued at $7 million. Most dwellings are along the Foreshore Rd.

Residential properties along Foreshore Rd and some along Kelso Jetty Rd and Greens Beach Rd would be susceptible to flooding, initially mostly of below floor level flood depths. From 2050 onwards, private property protection works could enable residents to continue to live there while managing risks to an acceptable level. Road access to some properties along Foreshore Rd would be lost during an extreme event.

Where floods do not come above floor levels, houses on properties that have high water tables may find that soil bearing capacity is affected and the structural stability compromised, leading to high repair costs or need to abandon.

Sections of Greens Beach Rd and New Rd would likely be subject to increasingly frequent flooding as a result of an extreme event, resulting in the roads being inaccessible during extreme rainfall and storm events. Over time (post 2050), an alternative route for Greens Beach Rd would need to be developed to ensure long term accessibility to Greens Beach and beyond.

Foreshore Rd would increasingly be subject to erosion and flooding, with sections of the road likely to erode away from 2050 onwards. Some private properties along Foreshore Rd are likely to erode away sometime after the road has eroded, likely before 2100.

While this scenario presumes 'nature takes its course', in practical terms there are already some existing coastal protection works. These would be allowed to deteriorate, or any hazardous remnants removed if necessary. New (re)development, filling of land and subdivision will be prevented by planning scheme amendments.

Increasingly, saline ground water would lead to a change in vegetation. Non-salt tolerant terrestrial plants, including many trees and shrubs, would become stressed and trees would die off and be replaced by more salt tolerant species. Land along Kelso Bay would gradually become wetland. The (rural) land between Foreshore Rd and Greens Beach Rd would become increasingly wet and will likely to turn into wetlands between 2050 and 2100.

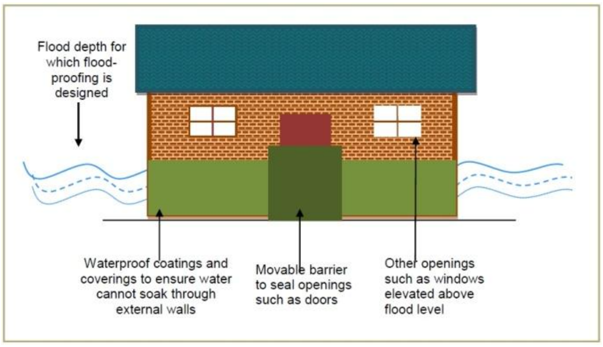
This plan would likely see most of the study area to be occupied to 2100, with some properties required to commence retreating from about 2050 onwards.

Likely options within this pathway

Major works and modifications to the landscape would not be permitted under this scenario. Most work would be involved in 'clearing away' and reconfiguring infrastructure to remain serviceable. In the short term vegetation management and access restriction to the foreshore will help minimising erosion. Other options include private action to reduce flood damage, repair and maintenance after events, and ultimately retreat.

The alternative route for low lying sections of Greens Beach Rd would be the most significant measure within this pathway, and may be required towards 2100.

Wetlands develop and move shoreward **Foreshore revegetation**



Flood proofing for existing buildings
http://climatetechwiki.org/sites/default/files/images/extra/media%20image%202_10.jpg

Action plan and indicative costing

Actions: 0-10 Year Timeframe (indicative cost $ 3,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$10,000
2	Planning scheme amendment to restrict development, filling and subdivision	C/State	Nominal
3	'Soft' foreshore protection works (vegetation and access restriction	C/residents	$20,000
4	Emergency management plans	State/C	Nominal
5	Advice to property owners on individual risk management measures	State/C	Nominal
6	Repair and modification of infrastructure after any flood, eorsion event as required to maintain agreed service levels	State/C	Increasing over time

Actions: 10-40 Year Timeframe (indicative cost $ 22,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$30,000
2	Emergency management plans update and review	State/C	Nominal
3	Advice to property owners on individual risk management measures	State/C	Nominal
4	Repair and modification of infrastructure after any flood, ersion event as required to maintain agreed service levels	State/C	Increasing over time
5	Disaster relief after major flood/erosion event and assistance to re-establish elsewhere	Federal/State	Increasing over time
6	Private, individual action to reduce flood damage risks	Property owners	$320,000
7	Requirements to remove uninhabitable dwellings; rehabilitation of abandoned blocks	C/property owners	$320,000
8	Allow wetland to develop	C	Nominal

7.2 Pathway 2 Protect existing development as long as practical while protecting natural values

This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community, such as the foreshore and the rural character of the land. There is balance between protecting natural and shared community assets, and private property. There is also consideration of promoting and sustaining natural ecosystems in the face of climate change. This would include permitting wetlands to develop and migrate inland in selected locations. In general, intensification of development in hazard areas would be discouraged unless it, and the protection measures required, clearly did not have any negative impact on natural and community values or have a positive effect.

Some modifications to the environment may be permitted. For example, part of a wetland might be excavated to provide fill to raise flood prone property but provision would be made elsewhere for wetlands to migrate inland. However, protection and adaptation options that result in changes to the character of the area that reduce its attractiveness and property value would not be pursued (eg levees).

How might things be with this pathway?

An additional groyne south of the existing one will likely minimise the impacts of erosion at least to 2050. The existing groyne will also be maintained and upgraded to 2050. The existing sea wall may need to be reinforced as sea level rises, as the sea wall will be overtopped more frequently during extreme events.

Shore protection works will protect Foreshore Road and dwellings until the frequency of works and related costs become impractical.

Inundation risks of existing dwellings will be managed by raising Foreshore Rd at the time it requires significant maintenance. Sections of Greens beach Rd and New Rd will be raised to ensure accessibility. Improved storm water drainage culverts under Greens Beach Rd and New Rd will be combined with designated drainage canals and a retention basin on the land between Foreshore Rd and Greens beach Rd.

Low lying properties would still need flood protection measures (eg flood skirts), and emergency planning until these measures were in place. Filling low lying land would be encouraged in presently developed areas behind the road barriers except the identified drainage lines. For smaller blocks, filling would be mandatory at the time of any building redevelopment. The drainage lines would become permanent open water ‘canals’ as sea levels rise.

New development and redevelopments/major extensions would be required to be built with the floor above the expected maximum annual high tide for the lifetime of the structure plus a freeboard allowance.

The undeveloped land between Foreshore Rd and Greens Beach Rd would likely become wetter. However, improved drainage canals and a retention basin are likely to allow the land to be used for agricultural purposes for a few more decades. Eventually the land would turn into wetland.

Properties along Kelso Bay would be allowed to fill the land and put revetment works in place to harden the foreshore.

This approach would likely permit most of Kelso to continue to be occupied for most of this century or longer. Under this scenario, if sea levels rise at rapid rates (say, more than 0.15 m per decade), either some retreat will be required or some development may need to float.

Likely options within this pathway

Under this pathway roads, infrastructure and houses in hazard areas will be allowed to be raised to adapt to rising sea levels. Within 10 years an additional groyne would be placed. Over time existing protection works would be maintained and reinforced. Improved storm water drainage management works include improved culverts, drainage canals and a retention basin. In the long run, a strategy of retreat would be followed.

Stormwater culvert

Wooden groyne

Elevated dwellings

Retention basin

Action plan and indicative costing

Actions: 0-10 Year Timeframe (indicative cost $ 36,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$10,000
2	Planning scheme amendment controlling filling so it does not adversely affect drainage or adjacent properties	C/State	Nominal
3	Emergency management plans	State/C	Nominal
4	Advice to property owners on individual risk management measures	State/C	Nominal
5	Development of stormwater drainage management plan	C	$20,000
6	Repair and modification of infrastructure after any flood, ersion event as required to maintain agreed service levels	State/C	Increasing over time
7	Additional groyne	C/property owners	$200,000
8	Maintenance and upgrade of sea wall and groyne	C/property owners	$100,000
9	Private, individual flood protection works	property owners	$30,000

Actions: 10-40 Year Timeframe (indicative cost $ 114,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$30,000
2	Emergency management plans - update and review	State/C	Nominal
3	Advice to property owners on individual risk management measures	State/C	Nominal
4	Repair and modification of infrastructure after any flood, ersion event as required to maintain agreed service levels	State/C	Increasing over time
5	Maintenance of existing protection works	C/property owners	$500,000
6	Stormwater management works (culverts, canals, retention basin)	S/C/property owners	$500,000
7	Private, individual hardening of residential foreshores Kelso Bay	property owners	$190,000
8	Private, individual action to reduce flood damage risks	property owners	$1,100,000
9	Raising roads (Foreshore Rd, section New Rd, section Greens Beach Rd))	S/C/property owners	$1,000,000
10	Filling of residential properties (re- and new development)	property owners	$100,000

7.3 Pathway 3 Protect existing development and permit new development to the maximum possible extent for as long as possible

This pathway concentrates on protecting the existing and future community and property. It assumes that the rate and extent of change will be manageable using available options and that any necessary protection and adaptation options will be acceptable. Intensification of development provides more contributors to any protection works, so some intensification is permitted where it does not compromise community values for the suburb. For example, low lying rural residential areas may be permitted to subdivide, making it more cost effective to fill lots as a way of combating inundation, while allowing sufficient floodways to control runoff. While natural areas may be affected, they will adapt in their own way or become modified in ways that the community accepts.

How might things be with this pathway?

A new groyne combined with maintaining and upgrading the existing groyne and sea wall can manage erosion risks at Kelso's foreshore for some decades.

With sea level rise, the increasing risks of erosion and inundation will eventually result in ever increasing maintenance and upgrading costs that will become impractical. To manage flood risks, a levee would be developed along the entire coastal community and where possible raise existing roads landward to form a protective barrier around Kelso. Foreshore Rd would be placed on top of the levee. Foreshore properties would lose their view, and the existing narrow foreshore strip would become open water with sea level rise.

A sea wall would reduce the need for individual properties to address flooding and erosion hazards. The costs of a sea wall, to be borne by those who benefit from it, are substantial and may be beyond the carrying capacity of the existing community. Significant intensification of development would be a means to generate sufficient ability to pay.

New development and redevelopment/major extensions would be required to be built with the floor above the expected maximum annual high tide for the lifetime of the structure plus a freeboard allowance. Land filling would be encouraged in all areas behind road barriers and levees except identified drainage lines and retention basins. Levels would be controlled to ensure effective drainage patterns with land further from the drainage lines and basins at higher levels than those on the edges. For smaller blocks, filling would be mandatory at the time of any building redevelopment. Some further subdivision of larger blocks may make filling these more cost effective and add to the number of contributors to protection works.

Streets serving these areas would be raised each time they were being rebuilt (ie within their normal service and renewal cycle) at an elevation that suited the adjacent blocks for their service life, in line with a progressive developing drainage plan. The plan would need to be quite prescriptive about filling and development to ensure that it would be effective. In some cases dwellings may be built with floors elevated well above surrounding ground level on a 'mound' for some years, with the surrounding area filled later to manage drainage effects.

This approach should permit most of the existing residential areas and some new developed areas to continue to be occupied for this century or longer. In the longer term, if sea levels rise by 2, 3 or more metres, the protection works along Kelso may need to become larger and more sophisticated. This may only be supportable with more intensive development of the area. Given the time from now until when this need arises (potentially of the order of 100 years or more) it is not realistic to predict the priorities and values of the community at that time. Quite high densities may be seen as appropriate as well as being better able to support more expensive protection works.

While this scenario proposes continued fill and shore armouring as the primary response, floating dwellings may also be used for some part of the area or to extend occupation of sheltered waterways acting as drainage points within the perimeter.

The costs of this pathway are likely to increase significantly from ten years from present day and onwards.

Likely options within this pathway

Under this pathway, significant engineering solutions will play a significant role including a levee, a sophisticated stormwater drainage management plan, filling of land and raising of properties, infrastructure and roads.

Areas outside the levee would be required to be designed and built to sustain high water levels. Intensification will be required to make protection and development feasible under this pathway. It may not be possible to bring development to such high levels in an area that is currently characterised as low density and low cost properties.

Dyke with coastal road, Holland

Retention basin

Houses elevated and designed for water levels

Fill to raise land levels

Action plan and broad costing

Actions: 0-10 Year Timeframe (indicative cost $ 36,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$10,000
2	Planning scheme amendment controlling filling so it does not adversely affect drainage or adjacent properties	C/State	Nominal
3	Emergency management plans	State/C	Nominal
4	Advice to property owners on individual risk management measures	State/C	Nominal
5	Development of stormwater drainage management plan	C	$20,000
6	Repair and modification of infrastructure after any flood, ersion event as required to maintain agreed service levels	State/C	Increasing over time
7	Additional groyne	C/property owners	$200,000
8	Maintenance and upgrade of sea wall and groyne	C/property owners	$100,000
9	Private, individual flood protection works	property owners	$30,000

Actions: 10-40 Year Timeframe (indicative cost $ 485,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$30,000
2	Emergency management plans - update and review	State/C	Nominal
3	Advice to property owners on individual risk management measures	State/C	Nominal
4	Repair and modification of infrastructure after any flood, erosion event as required to maintain agreed service levels	State/C	Increasing over time
5	Maintenance of existing protection works	C/property owners	$500,000
6	Stormwater management works (culverts, canals, retention basin)	S/C/property owners	$500,000
7	Construction of levee at Foreshore Rd	C/property owners	$12,500,000
8	Raising roads (sections Jetty Rd, New Rd and Greens Beach Rd)	S/C/property owners	$1,000,000

7.4 The community workshops

Three adaptation pathways were explored by community members from the Kelso community at a workshop held on Sunday 1 December 2013 with sessions held in the morning and the afternoon. A total of approximately 49 community members (there are just over 150 properties in the study area) attended the workshops and most attendees participated throughout the day.

The community workshops started with an informative section presenting the project findings, responding to questions and explaining the remainder of the day which included two rounds of workshop sessions.

Each participant was given the opportunity to attend two workshops, one in the morning and one in the afternoon. Three sessions, each exploring one adaptation pathway, were run simultaneously in the morning and in the afternoon.

The three pathways were:

1. **Let nature take its course and retreat early.** This pathway allows maximum freedom for natural coastal processes to unfold, with a minimum of intervention or resistance from future development or coastal and flood protection works. Where erosion threatens structures, they would be removed. Where property is regularly inundated, it would eventually not be worth repairing and redevelopment in affected areas would not be permitted.

2. **Protect existing development as long as practical while protecting natural values.** This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community. There is balance between protecting natural and shared community assets, and private property. There is also consideration of promoting and sustaining natural ecosystems in the face of climate change. In general, intensification of development in hazard areas would be discouraged unless it and the protection measures required clearly did not have any negative impact on natural and community values or were likely to have a positive effect.

3. **Protect existing development and permit new development to the maximum possible extent for as long as possible.** This pathway concentrates on protecting the existing and future community and property using any available options. Intensification of development provides more contributors to any protection works, so some intensification is permitted where it does not compromise community values for the suburb. While natural areas may be affected, they may adapt in their own way or become modified in ways that the community accepts.

All participants were informed that the pathways are not predictions or recommendations, but ways of imagining different futures based on a range of choices about how to respond to climate change effects. All pathways are based on two principles:

- **developing risk will be actively managed;**
- **people cannot be subsidised to occupy or use hazardous locations.**

Each workshop session lasted up to two hours, enabling an in-depth investigation of the pathway. At the start of each session the participants were asked to read the flyer explaining the pathway, the types of adaptation options likely to be adopted and how things may be different with that pathway. After that the workshop moderator summarised the pathway and answered any questions before starting to explore the pathway.

Over the two hours participants examined the following for the scenario they were investigating:

- The pros and cons and desirability of the scenario
- Whether they believed the scenario was plausible
- What if conditions change (eg. sea level rises faster or slower than anticipated, there are technological advances, or property prices rise or fall)

- Who decides
- Who pays

After exploring these questions participants were asked what pathway they think is a realistic option for the Kelso study area.

7.5 Workshops summary

The community members appreciate living in Kelso because of its strong community and the location along the Tamar River with its beach and other natural values. The residents enjoy the fact the community is small and many properties have been within the family for multiple generations. There is a strong desire among the community members to keep everything the way it currently is[21].

Overall, there was significant consensus within the pathway 2 sessions and also in the pathway 1 and 3 sessions, that pathway 2 would be the preferred way forward. Key benefits of this pathway include:

- The community and amenity values of the area are largely maintained: the lifestyle and the beach were especially referred to
- It is a doable pathway that is largely within the community's resources and capabilities with little support from outside
- This pathway addresses current day issues especially in regard to storm water management and foreshore erosion. Or as one community members put it: *"Even without climate change this pathway is necessary"'*
- It is more cost effective than both pathway 1 and 3; pathway 1 may result in a considerable loss of property and pathway 3 is costly in terms of protection works and will be well beyond the bearing capacity of the community
- The changes required for pathway 3 would not be implemented until several decades from now, after the pathway 2 options were no longer sufficient. There would be no reason to commit to such a pathway already.

It was generally seen as the only way forward.

Negative aspects of Pathway 2, as raised by the community members include that the costs would largely need to be borne by the community, Council, State and other stakeholders. Pathway 2 also does not offer an end solution. If sea levels continue to rise, the community still needs to decide between retreat or protect.

Pathway 1 was not favoured by the community members. Key negative aspects of this pathway are that it does not protect the community, property prices may drop, properties would be lost over time and that future generations would not be able to enjoy the area as it is today.

Pathway 3 provides protection for property in the long term and therefore allows future generations to enjoy the area. The safety offered by protection may attract more people to the area and add to property values. The main disadvantage of this pathway is that the costs are likely to be prohibitively high and well beyond the bearing capacity of this community. This pathway would require significant intensification and higher density development for protection works to be affordable. Pathway 3 was characterised as being accepted as a last resort. Or as one community member put it: *"No one is going to walk away (red: from managing the risks) but we don't have billions of dollars to spend. Let's go with Pathway 2 for the time being."*

[21] With sea level rise, retaining the status quo is not an option, even if one would decide to do nothing, changes are eminent with continued sea level rise.

7.6 How to make it work? Community perspective

Present day issues

Members of the community present at the workshop expressed some concern about present day issues - most notably storm water drainage and the high water table (which further exacerbates drainage issues). There was a perception amongst the community members that the storm water drainage issues are not being addressed by Council to their expectations. The discussion noted that drainage lines have collapsed on many locations and do not appear to be sufficiently maintained. There was some confusion amongst the participants as to whether the drainage lines may be on privately owned land and what the roles and responsibilities are for maintaining and upgrading this infrastructure. There were also concerns about the high and rising water table may affect sceptic systems.

It was expressed at multiple occasions that the community members would prefer the Council to focus on current day drainage issues before coordinating and planning adaptation actions for the future.

There was also concern expressed that while Council now requires new construction to be elevated above expected flood levels allowing for sea level rise, Council did not appear to commit to elevating roads servicing these new and existing properties.

Decision making and coordination

There was consensus that all stakeholders, the community, Council, State and Federal Government need to cooperate to manage the risks. This required a clear understanding of the roles and responsibilities.

The community members expressed that their community would be able to address at least some of the issues themselves with little help from other stakeholders. Decision making should to a large degree be in the hands of the community (via a community board) in partnership with Council.

The community members agreed there is a need for an adaptation plan for the area with a clear timeframe, and for monitoring and review of key data on climate change and its impacts to guide the adaptation process.

Funding

It was suggested that a portion of the rates paid by Kelso residents should be set aside to fund adaptation in the area. There was a general dissatisfaction in the community at the perceived the return in Council services for the rates the community contributed. However, as was made clear by the moderator of the session, even the entire current rates base would unlikely be sufficient to meet the costs of adaptation over time. There was some agreement the community may have to contribute over and above current rates. The community recognised its limited ability to pay, and started exploring how the community may actively work/contribute towards adaptation. This may however put a significant burden on a few very active community members.

The community believes it would be able to progress some of the elements of their preferred pathway within existing resources, but that there would also be a need for additional funding. Creative solutions may be utilised, such as work for the dole program.

8 WHERE TO FROM HERE?

This section provides overall conclusions on the project, the assessments, and the stakeholder consultation findings. In broad terms it provides direction to the way forward. Many lessons have been learned, but also, it is clear many gaps in terms of knowledge, decisions making and funding still exist. The following conclusions will illustrate this and also suggest possible ways to address issues. Interestingly enough, the findings are largely true for other case study areas too (both the first TCAP and the TCAP Extension project of which Kelso is part of). The consistency in findings supports us in our conviction that some of the issues can and should be addressed collectively and at a State (or even national) level.

Addressing present day issues

The general consensus in the community is that there are significant present day issues in regard to storm water drainage. From discussions during the sessions it is our understanding that stormwater drainage issues are significant at the properties at the foreshore, especially south of New Rd. Anecdotal evidence suggests many drainage canals have collapsed thereby preventing storm water to drain effectively. It appears that drainage canals, at least some of them, are on privately owned land and that there is no mechanism in place to effectively maintain drainage canals. It is unclear what parties are responsible for this. There is a need for a coordinated approach between the responsible parties to address the issue. There is frustration within the community why nothing is done to improve the drainage capacity, and Council is generally seen as the party most likely to be responsible for this. For the community this would need to be addressed as a matter of urgency.

Recommendation: Even if Council has limited responsibilities in regard to maintaining/upgrading storm water canals on (privately owned) land, it is recommended that Council informs the community about the responsibilities of various land owners and managers. Since it appears that a multitude of land owners is involved, it is further recommended Council takes on a coordinating role to guide responsible parties in addressing the issue.

Some of the short term options to manage erosion such as vegetation management and car access to the beach could possibly be implemented in the short term.

Decision making and funding

Community members would support a decision making framework where the community works in partnership with Council to manage adaptation.

A process for agreeing a plan and reconciling different interests has been proposed in a paper prepared to ‘reality check’ the proposed pathway for Lauderdale in Clarence: *Decision Making and Funding for Coastal Adaptation*. This proposes that an adaptation management plan would be developed and formally adopted under a State government framework. The process would have parallels with the development of a planning scheme with opportunities to make representations and appeals, and input from state agencies and review by an authority to confirm compliance with relevant legislation. By having State backing, it would reduce the burden on Local Government for any impacts arising from implementing the plan. The content of this paper would equally apply to Kelso, or any other community in Tasmania facing similar issues.

At present the State does not provide a framework to enable such a plan to be prepared and recognised.

Recommendation: To work with the state government to develop a framework for the development of coastal adaptation plans that have state backing and recognition, and balance the priorities of both the local and wider community.
Recommendation: For Council to work in partnership with the community to determine roles and responsibilities for coordinating and administering coastal adaptation, and to consistently communicate and consult with the community and other stakeholders.

Longer term strategic planning and monitoring

The hazards from inundation and potential erosion have been documented by the project for present day and for sea level rise of 0.2 and 0.8m. However, the projected impacts of erosion are still fairly uncertain and depend on detailed (geomorphological) studies of specific locations along the foreshore

This work would also inform decision making on (the feasibility) of any adaptation options such as storm water infrastructure and groynes or other sediment trapping options. The community expressed a strong desire to retain the beach and natural amenities in the area. Both this and the community's expectations that the community would not be able to afford some hard protection works (such as a sea wall) suggest the investigations would need to consider soft adaptation measures primarily.

To minimise future exposure to risk, especially if pathway 1 or even 2 is adopted, future new development in areas at considerable risk would need to be minimised and be allowed only if certain criteria are met. It is important Council commits to service delivery to properties that have been approved, at least for the lifetime of the investment.

Recommendation: Ensure a framework is in place to ensure appropriate research is done to make decisions on the basis of evidence.

Adaptation requires funding

Both the recommended investigations above and the works required for adaptation will require significant funds. Clarence City Council has spent close to $500,000 to date and the most recent investigations further changed the recommended response significantly from that suggested by earlier, less detailed work. It appears that there are few shortcuts to achieving a good understanding of the local issues that need to be addressed to adapt to climate change in a responsible way.

Under the principle put forward in the TCAP project that there will be no subsidy to assist people to occupy hazardous locations, and consistent with the recommendation of the report on funding and decision making, it is expected that the funds would be raised partially by a special rate levies on property within the identified hazard areas. Some transition assistance may be available from national or state programs to support climate change adaptation, emergency planning or other relevant programs.

Recommendation: That an approach be formulated to identify the budget required and the sources of funds to raise the money required. It is considered that this should be done on a staged basis over a period of about 5 years, with priority given to identification of and responding to storm water management and erosion risks.

Appendix 1 Planning Codes

Clause E3 Change in Existing or Natural Ground Level Code

The purpose of this provision is to minimise impact of change in existing or natural ground level.

Development Standards for the Change in Existing or Natural Ground Level Code are provided in Clause 3.6.

Objective: Change in the existing ground level or the natural ground level by cut or fill are to minimise likely adverse impact on the physical, environmental, cultural, and amenity features of land or for inconvenience or risk to adjacent land.	
Acceptable Solution	Performance Criteria
A1 Cut or fill must – a) not be on land within an area of likely risk from a landslide hazard;	P1 Cut or fill must - b) be assessed in accordance with Code E6 as being unlikely to trigger, spread, or intensify risk of landslide.

Clause E6 Hazard Management Code

The purpose of this provision is to –

a) identify likely areas of risk for use or development on land exposed to natural or environmental hazard;
b) minimise likely social, economic, and environmental costs associated with exposure of use or development to an unacceptable level of risk from a natural or environmental hazard;
c) minimise likelihood for use or development to trigger, spread, or intensify a natural or environmental hazard;
d) apply controls to manage likely risk that are proportional to the type, intensity, and anticipated life of use or development

This Code applies for use or development on land in an area exposed to likely risk from a natural or environmental hazard because of –

a) coastal inundation and erosion by sea level rise or storm surge[22] if –
   i. shown on the planning scheme map;
   ii. (if no area is shown on the planning scheme map) land within landforms defined as vulnerable to erosion or regression in Indicative Mapping of Tasmania Coastal Vulnerability to Climate Change and sea Level Rise (Sharples 2006); or
   iii. below 5.0m AHD; or
   iv. Shown on the Coastal Inundation Map prepared for the Tasmanian Planning Commission 2011.

c) Flooding[23] from a watercourse, wetland or stormwater disposal system if –
   i. shown on the planning scheme map; or
   land within the overland flow path for the 1% annual exceedance probability flood in a watercourse, wetland or stormwater disposal system

d) landslide[24] shown on the Landslide Hazard Map prepared by the Department of Premier and Cabinet

[22] TPC has advised it is to initiate preparation of a mandatory common provision by a Code for coastal flooding and erosion
[23] Draft Planning Directive – Statewide Codes – *Flood Prone Land Code* (2011) awaiting panel decision and Ministerial approval

A definition of terms is provided in Clause 6.3, including definitions for "critical use", "hazard risk assessment", and the difference between high, medium, low and acceptable levels of likely risk. The full definition of terms can be found in the appendix of this document.

Use Standards for the Hazard management Code are provided in Clause 6.5.

Objective: The level of likely risk from exposure to a natural or environmental hazard is to be tolerable for the type, scale, and intensity of each use	
Acceptable Solution	Performance Criteria
A1 a) The site must be within an area for which there is an acceptable level of risk; or b) The use must not be a critical use, vulnerable use or hazardous use on land within an area exposed to a level of likely risk that is not an acceptable level of risk unless a hazard risk assessment indicates there is an insufficient increase in the level of risk to warrant any specific hazard reduction or protection measures	P1 a) There must be a hazard risk assessment if - i. critical use, vulnerable use or hazardous use on a site within an area exposed to a low level of likely risk; or ii. any use on a site within an area exposed to a medium level of likely risk or an area exposed to a high level of likely risk; and b) The hazard risk assessment must indicate – i. there is an insufficient increase in the level of risk to warrant any specific hazard reduction or protection measures; or ii. a hazard management plan to demonstrate a tolerable level of risk can be achieved and maintained for the type, scale and intensity of the development; and c. If the hazard management plan involves land external to the site, the consent in writing of the owner of that land must be provided to enter into a Part 5 agreement to be registered on the title of the land and providing for the affected land to be managed in accordance with the hazard management plan b) There must be – i. an overriding benefit to the community; and ii. no suitable alternate site; if - i. critical use on a site within an area exposed to a medium level of likely risk or a high level of likely risk; or ii. vulnerable use or hazardous use on a site within an area exposed to a high level of likely risk

Use Standards for the Hazard management Code are provided in Clause 6.6.

Objective: The level of likely risk from exposure to a natural or environmental hazard is to be tolerable for the type, scale, and intensity of each development	
Acceptable Solution	Performance Criteria
A1 a) The site must be within an area for which there is an acceptable level of risk; or b) If the site is within an area exposed to a low level of likely risk development must – i. be an alteration or addition to an	P1 a) A hazard risk assessment must indicate a hazard management plan to demonstrate a tolerable level of risk can be achieved and maintained for the type, scale and intensity of the development if the site is within -

[24] Draft Planning Directive – Statewide Codes –*Landslide Code* (2011) awaiting panel decision and Ministerial approval

existing building or a minor building, structure, or work; ii. be infill or redevelopment; or iii. be subdivision to create not more than 3 new lots by infill within an area of established use; or c) A hazard risk assessment must indicate there is an insufficient increase in the level of risk to warrant any specific hazard reduction or protection measures	i. an area exposed to a low level of likely risk and development is for – a. a critical use, a vulnerable use or a hazardous use; b. a new building, structure or work; c. subdivision to create 3 or more new lots; d. subdivision to extend an existing highway; or ii. an area exposed to a medium level of likely risk and development is for - a. alteration or addition to an existing building or a minor building, structure, or work; b. infill or redevelopment for a purpose permitted within an area of established use; or c. subdivision to create not more than 3 new lots by infill within an area of established use; d. subdivision to extend an existing highway; e. a critical use, a vulnerable use or hazardous use; or iii. any development on a site within an area exposed to a high level of likely risk; and b) if the hazard management plan involves land external to the site, the consent in writing of the owner of that land to enter into a Part 5 agreement to be registered on the title of the land and providing for the affected land to be managed in accordance with the hazard management plan

Clause E12 Water and Waterways Code

The purpose of this provision is to assist protection and conservation of a water body, watercourse, wetland or coastal shoreline area for –

a) ecosystem diversity and habitat value of native flora and fauna;
b) hydraulic capacity for water quality, yield, water table retention, flood flow, and waste water assimilation;
c) economic and utility importance to primary industry, settlement, industrial, irrigation and energy generation purposes;
d) aesthetic and recreational use

Development Standards for the Water and Waterways Code are provided in Clause 12.6.

Proximity to a water body, watercourse or wetland [25]

Objective: Development within or adjacent to a water body, water course or wetland is to have minimum impact on a) the ecological, economic, recreational, cultural significance, water quality, and physical characteristic of a water body, watercourse or wetland; b) the hydraulic capacity and quality of a water body, watercourse or wetland for ecological viability, water supply, flood mitigation, and filtration of pollutants, nutrients and sediments;

[25] Clause 6 removes the exemption for operation of the planning scheme for use or development on land within 30m of a watercourse or wetland. In the event use or development occurs within 30m of a watercourse or wetland the use or development is prohibited unless the planning scheme includes provisions for assessment.

c) function and capacity of a water body, watercourse or wetland for recreation activity; and d) aesthetic features of a water body, watercourse or wetland in the landscape	
Acceptable Solution	Performance Criteria
A1 Development must not – a) occur within 30m of the shoreline of a water body, watercourse or wetland; or b) involve any use or development partly or wholly in, over, on or under the water body, watercourse or wetland	P1 The nature, scale, and intensity of development within 30m of the shoreline of a water body, watercourse or wetland; or partly or wholly in, over, on or under a water body, watercourse or wetland must – a) include adequacy and appropriate measures to minimise or manage risk to the function and values of a water body watercourse or wetland[26], including for – iv. disturbance and change in natural ground level, including by cut or fill; ix. modification of a natural drainage channel xi. level of likely risk from exposure to natural hazards of flooding and inundation; and xii. community risk and public safety

Development in a seashore area

Objective: The coastal zone and sea-shore are protected against likely adverse impact on economic, ecological, scenic, cultural, and recreation values and processes of the coast while facilitating use dependent for operational efficiency on a coastal location.	
Acceptable Solution	Performance Criteria
A1 Development must be – b) an existing building or work wholly or partly in the sea-shore area; i. risk management, emergency or rescue purposes; or ii. public access and recreation	P1 Development must: h) not have immediate or cumulative adverse effect for – i. tidal, wave, current, or sediment movement processes; ii. coastal landforms, seabed, and other geomorphic features, including sand dunes and mobile landforms; iv. drainage from a water course, wetland, ground water, flood, stormwater, or tidal water; viii. exposure to or increased risk from a natural hazard, including sea level rise, storm surge, or inundation as a result of climate change; ix. coastal protection and rehabilitation works required to address erosion, instability, regression, or inundation; x. collection, treatment, and disposal of waste, including bilge waters and excavated or dredged sediment; xii. public safety and emergency services;

[26] Regard is to be had to the level of compliance to the methodologies and recommendations of the current edition of Wetlands and Waterways Works Manual DPIPWE 2003;

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