Adapting Northern Adelaide

Planning for our changing climate

Photo by Bill Doyle

Climate Change Adaptation Plan for the Northern Adelaide Region

Climate change adaptation plan for the Northern Adelaide region

A plan prepared for the City of Salisbury and City of Playford

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Acronyms

AMLR - Adelaide and Mount Lofty Ranges
ANA - Adapting Northern Adelaide
AR5 - Fifth Assessment Report
CCIA - Climate Change in Australia
CSIRO - Commonwealth Scientific and Industrial Research Organisation
DAFF - Department of Agriculture Fisheries and Forestry
DEWNR - Department of Environment, Water and Natural Resources
ENSO - El Niño Southern Oscillation
FFDI - Forest Fire Danger Index
GCM - Global Climate Models
IIASA - International Institute for Applied Systems Analysis
IOD - Indian Ocean Dipole
IPCC - Intergovernmental Panel on Climate Change
IVA - Integrated Vulnerability Assessment
NRM - Natural Resource Management
PIRSA - Primary Industries and Regions, South Australia
RCP - Representative Concentration Pathways
SA - South Australia
SACR - SA Climate Ready
UHI – Urban Heat Island
WSUD – Water Sensitive Urban Design

Executive summary

Climate change is already impacting the way we live, how our economy performs and the way the natural world functions. With continued emissions of greenhouse gases, the Earth is committed to further warming and associated climate changes over the coming decades.

For Northern Adelaide, climate change will mean warmer and drier conditions, increased risk of climate hazards such as extreme heat, fire and flooding, and changing conditions in Gulf St Vincent like rising sea levels.

Changes in the future climate will present risks and opportunities. The region must address the risks to build resilience in its community, economy and environment, but also harness emerging opportunities by building an adaptive economy.

Implementing regional adaptation priorities will require continued collaboration across industry and government partners and awareness raising amongst the broader community.

Context

Adapting Northern Adelaide (ANA) is a partner project between the City of Salisbury, City of Playford, the South Australian Government, and the stakeholders and communities that live and work in the Northern Adelaide region. The focus of the ANA project is to respond to climate change by:

> *"building liveable communities underpinned by a prosperous economy and sustainably managed natural resources."*

Despite global action on climate change to reduce greenhouse gas emissions, the Earth is already on a pathway which means that substantial adaptation will still be required. By being proactive and thinking and planning now for the impacts that are already happening and also those that are likely to occur in the future, the Northern Adelaide region can build resilience to risk and harness any emerging opportunities.

This Regional Climate Change Adaptation Plan (Adaptation Plan) provides the foundation for a coordinated and collaborative response to climate change impacts and identifies priorities for adaptation across the ANA region.

The adaptation responses proposed in this Adaptation Plan align strongly with current and emerging policy initiatives at a State and Federal Government level, such as South Australia's Low Carbon Economy and Green Industries programs, and the Federal Government's Smart Cities Plan.

Climate change in Northern Adelaide

While there is natural variability in the Northern Adelaide region, climate change will create a different future climate with warmer and drier conditions, increased risk of extreme events such as heatwaves and fire, and higher sea levels. The outcomes for the region from the high emissions scenario (upon which the Earth is currently tracking) are summarised below, with further details available in the *Climate Change Projections for Northern Adelaide* report (Adapting Northern Adelaide, 2015a).

For the Northern Adelaide region in 2070 and under a high emissions scenario:

- annual rainfall is projected to decline by about 11%;
- rainfall intensity could increase by 16%;
- annual maximum temperatures are projected to increase by 2.3ºC;
- annual minimum temperatures could increase by 2ºC; and
- extreme heat days per year (i.e. days >35ºC) in Gawler and Adelaide (closest available to the region) could increase by 76% to 82%, respectively (equivalent to 31 or 44 days, respectively).

Fire weather for Northern Adelaide, based on projections for Adelaide, project an increase of severe fire danger days (incorporating the severe, extreme and catastrophic CFS fire ban day classifications). General fire weather danger is projected to increase by 2030 by 13% under a high emission pathways, and by 29% by 2090. Longer dry periods leading into and throughout the fire danger season are also likely to cause drier vegetation that will create an additional risk on severe fire danger days.

For ocean and gulf waters, projections under high emissions suggest a:

- rise in median sea levels of about 41cm by 2070 (61 cm by 2090);
- rise in sea surface temperatures of 2.2ºC by 2090; and
- decline of 0.32 pH units by 2090.

Process

The Adaptation Plan has been developed via a three-stage process.

- Stage 1 - Background investigations and prioritisation, which included preparation of a regional profile, development of a climate projections report, and a review and prioritisation of strategic impact areas;
- Stage 2 - Vulnerability assessment, which involved undertaking an integrated vulnerability assessment for high, medium and low priority strategic impact areas; and
- Stage 3 - Adaptation action planning, which included the *Adapt Your Patch* online campaign, undertaking the adaptation pathways process and preparation of this Adaptation Plan.

The approach has been delivered with strong input key stakeholders and subject matter experts. In all, over 130 people attended project workshops and focus groups, representing over 40 organisations.

The integrated vulnerability assessment determined which sectors in the region should be the focus for identifying adaptation options. This was done by developing “key areas of decision making” using the results of the vulnerability assessment, the themes of which are as follows:

- Adaptive economy;
- Climate-ready buildings;
- Coastal ecosystems;
- Extreme events and emergency management;
- Health and safety of vulnerable people;
- Horticulture – Northern Adelaide Food;
- Natural landscapes;
- Public open space and recreation; and
- Water dependent ecosystems.

Priority adaptation options were identified for each key area of decision making and analysed using an adaptation pathways approach to determine which options should be implemented now, and which will need to be implemented at some time in the future. In addition, regional priority adaptation options were identified through the use of an action prioritisation framework, which combined the results of a qualitative cost-benefit analysis with consideration of regional relevance and the practicality of implementation.

The regional adaptation priorities for Northern Adelaide are:

1. **Building natural buffers to sea level rise**
    - Continue and maintain modelling and mapping to assist with risk management; and
    - Restore coastal and marine habitats.

2. **Creating liveable communities through climate-ready developments**
    - Prepare guidelines for developers and builders on how to encourage greater use of climate-ready building techniques and site development;
    - Identify barriers to implementing suitable climate-ready housing under the existing provisions of the Building Code of Australia;
    - Propose amendments to the Building Code of Australia and council development plans to overcome barriers to climate ready buildings; and
    - Raise community and industry awareness about the benefits of climate-resilient buildings, developments and urban environments.

3. **Reducing the risk of climate hazards to community health and well being**
    - Identify areas where “at risk development” should not be located ensure Development Plan amendments guide development that is resilient to climate impacts; and
    - Review local risks and responses to climate event hazards.

4. **Adapting the economy through investment in horticulture**
    - Develop better training and language communication support in areas such as soil and salinity management;
    - Improve land and water management practices; and
    - Use alternative water sources.

5. **Smart investment in urban green space and natural environments that underpin community and economic prosperity**
    - Develop connected green and blue spaces and corridors;
    - Increase appropriate tree planting rates in urban areas;
    - Make design allowances for increases in extreme events; and
    - Prepare ‘climate-ready’ guidelines for plant selection, landscaping, water management and any irrigation needs for open space planning and management.

6. **Supporting resilient natural landscapes**
    - Better managing threats such as pests and diseases;
    - Encouraging land-use changes with positive biodiversity outcomes;
    - Protect existing natural features;
    - Restore natural landscapes; and
    - Strategic planning to ensure positive biodiversity outcomes.

7. **Green industries for a prosperous and vibrant local economy**
    - Northern Adelaide Green Industries Program.

Implementation

Moving from the planning to implementation stage for Adapting Northern Adelaide will require a focus on:

- supporting options that look for opportunity and also address risk;
- preparing the business case for specific new actions action in order for projects to be included in budgeting processes or integrated into existing projects;
- working collaboratively across regional partner organisations; and,
- raising awareness amongst the community and businesses of the impacts of climate change and how we can respond.

An Adapting Northern Adelaide - Implementation Plan will guide the ongoing implementation of actions including processes for governance, monitoring, evaluation of success and review.

The Implementation Plan will describe the role of the Councils and practical actions that will be undertaken towards achieving priority adaptation outcomes.

The Implementation Plan will identify the best approach for progressing priorities as follows:

- for some adaptation priorities, Council divisions and teams are well placed to integrate adaptation actions into existing services, planning and reviews (such as for stormwater management planning or open space planning);
- other government agencies and organisations may be best placed to take the lead role for priorities in the public realm. These could include (but are not limited to) the Department of Planning, Transport and Infrastructure (DPTI), the Department of Environment, Water and Natural Resources (DEWNR), the Adelaide Mount Lofty Ranges Natural Resource Management (AMLR NRM) Board, and the Department of Primary Industries and Regions SA (PIRSA). For priorities led by other agencies, Councils may contribute supportive actions and assist in coordination and engagement activities; and
- new projects, programs and initiatives which have an additional budgetary requirement will need to be considered in annual council budgeting processes, and if approved, would be led by councils.

Coordination and advocacy would play a key role to enhance success by linking the local knowledge of councils with engagement opportunities and partnerships that will help to attract funding, advocate for policy reforms, and facilitate a regional approach to adaptation.

Most of the priorities identified in this plan are options that require immediate implementation. Yet the adaptation pathways approach also covers a number of more transformational options that will still be required in the future. Planning and further analysis of these options, which could result in greater costs and impacts for community and industry, such as relocating infrastructure in high risk areas, should commence now. Knowing when these future options should be implemented should be informed by identifying and monitoring triggers that relate to each key area of decision making.

1 Introduction

Adapting Northern Adelaide (ANA) is a climate change adaptation planning project covering the City of Salisbury and City of Playford local government areas (**Error! Reference source not found.**). It is a partner project between the Cities of Salisbury and Playford, the South Australian Government and the stakeholders and communities that live and work in the Northern Adelaide region. The project is also supported by the Federal Government under the National Disaster Resilience Program.

By collaborating, the Northern Adelaide region can deliver a coordinated response to climate change and by sharing information, resources, responsibilities and actions, resilience can be built to the benefit of the community, businesses and the environment.

The Northern Adelaide Region has already demonstrated world leading achievements in water management and wetlands creation with multiple benefits for amenity, for community industry, horticulture and biodiversity. Based on strong foundations and achievements, this Climate Change Adaptation Plan (henceforth Adaptation Plan) provides a framework for a coordinated and collaborative response to climate change and identifies priorities for adaptation across the region. The adaptation responses proposed in this Adaptation Plan align strongly with current and emerging policy initiatives at a State and Federal Government level, such as South Australia's Low Carbon Economy and Green Industries programs, and the Federal Government's Smart Cities Plan. It also addresses the requirements of the South Australian Climate Change Adaptation Framework for regions in the State to develop regional climate change adaptation plans.

The objective of this Adaptation Plan is to:

- provide an overview of how climate change is likely to impact the Northern Adelaide region;
- summarise the process involved in preparing the Plan, covering outcomes from previous stages;
- describe the key areas for adaptation planning, referred to as "key areas of decision making";
- identify priority adaptation options for each key area of decision making; and
- outline the regional priority adaptation options and timing of implementation through pathways mapping.

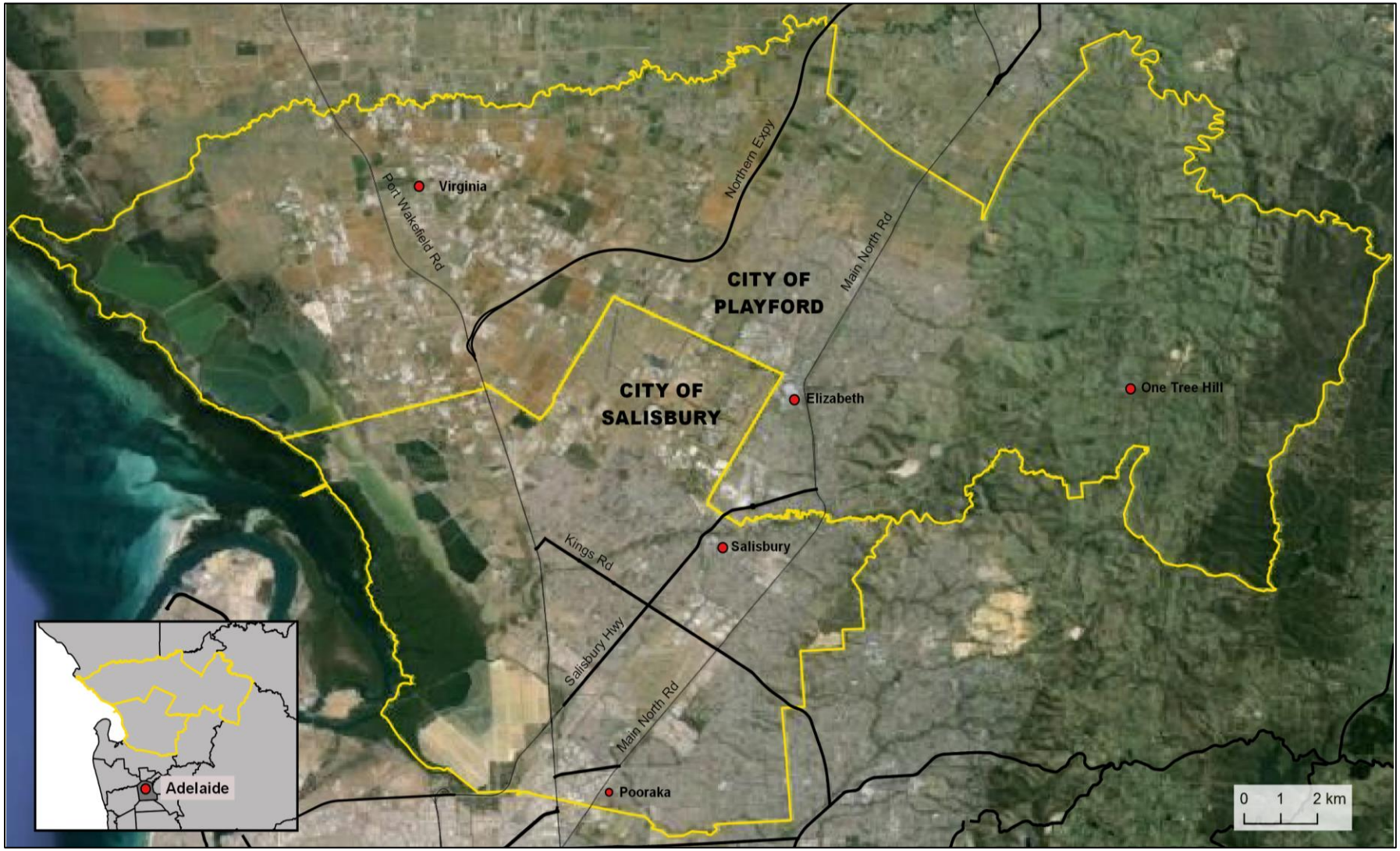
The Adaptation Plan is presented in three main parts:

Context (Sections 2-4): provides an overall introduction to the project and the region, projected climate changes for the region, and a summary of how this Plan has been developed;

Options (Section 5): presents the priority adaptation options and adaptation pathways for the region;

Implementation (Section 6): focusses on understanding the business-case for action and strategies required for successfully implementing the plan. It highlights opportunities for the Region and discusses the plan review.

This Adaptation Plan is a plan for the region and its implementation resides with individuals and organisations across the region including service providers, State and local government agencies, not-for-profit organisations, business and industry, infrastructure owners and managers, and community groups.



Main towns
Regional area boundary
Local government areas (inset map)
Arterial roads
Main roads

Figure 1. Northern Adelaide region.

Created: 09/06/15 **Drawn:** J.Garden
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Data source/s: sa.gov.au; google earth imagery

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www.seedcs.com.au

2 The Northern Adelaide region[1]

The Northern Adelaide region is comprised of two local government areas: the City of Salisbury and City of Playford, with the southern boundary of the region located approximately 10km north of the Adelaide CBD. The City of Playford has an area twice as large as the City of Salisbury (345km^2 and 158km^2, respectively) and together the two councils cover a land area of approximately 503km^2. The region falls entirely within the Adelaide and Mount Lofty Ranges Natural Resources Management region.

The region experiences annual average temperatures of 22.4ºC, with average monthly maximums during summer of 27.7 – 29.6ºC, and individual daily maximum temperatures of up to 45 ºC. Average monthly maximums during winter range between 15.1 – 16.3ºC. Rainfall varies across the region with lower annual averages on the plains such as 423mm and 452mm at Bolivar and Parafield Airport, respectively, compared with 570mm at Gould Creek (Little Para Reservoir) in the north eastern corner of the region.

Like much of the State, the Northern Adelaide region has a Mediterranean climate and as such experiences natural variability in weather during the year, characterised by hot, dry summers and cold, wet winters. Climate patterns vary year to year as well as with major climate influences (Bureau of Meteorology, 2016) including the:

- Indian Ocean Dipole (IOD), which affects the climate of Australia and other countries that surround the Indian Ocean Basin, and is a significant contributor to rainfall variability; and
- El Niño Southern Oscillation (ENSO), the oscillation between El Niño and La Niña conditions which affects rainfall and temperature in eastern Australia.

The result of these and other climate influences are natural and major variations in rainfall and temperature, especially drought cycles. In addition to this natural variability in climate, there are longer-term changes in rainfall, temperature and other variables occurring as a result of climate change.

[1] The information contained in this section is taken from the *Regional Profile for Northern Adelaide* report (Adapting Northern Adelaide, 2015b).

Supporting some of the State's major industrial and primary production areas (e.g. Northern Adelaide Plains), adaptation to climate change in the Northern Adelaide region is important not only for local residents and business owners, but also for the produce supply and economic well-being of the State in a national and international context. Combined, the two council areas have a Gross Regional Product of $8.12 billion, representing about 8.9% of the State's economy.

In 2012, the region supported a population of 217,306 people (~13% of State population), with the majority living in Salisbury (62%). The *30 Year Plan for Greater Adelaide* (Department of Planning and Local Government, 2010) projects the Northern Adelaide region (which includes City of Tea Tree Gully) will increase its population by 169,000 people by 2040, with 46,300 coming from infill within existing transit corridors and 81,300 occurring outside existing transit corridors through fringe growth.

Four times as many young people (<15 years) live in the region as elderly people (> 74 years). Average population density varies between the two council areas, with Salisbury having 3.5 times more people per square kilometre than Playford (849.8/km^2 and 204.6/km^2, respectively), a reflection of the large areas of farming rather than residential land comprising Playford.

Adaptation planning in the region should have regard to the following features (Adapting Northern Adelaide, 2015b):

- a multicultural population;
- relatively high proportion of households with a car;
- relatively low average proportion of lone-person households;
- relatively high proportion of households with internet access;
- active initiatives aimed at diversifying the region's economy;
- major transport infrastructure initiatives (i.e. northern expressway);
- creation of nationally and internationally important bird sanctuary and tourism destination (i.e. Adelaide International Bird Sanctuary);
- close proximity to export facilities located in Port Adelaide;
- relatively high number of community and recreation facilities (e.g. community centres, libraries); and
- dedicated emergency management protocols and networks (e.g. bushfire-related planning and building requirements, mapped bushfire protection and risk areas and metropolitan and country fire services, health care services, and police stations).

Northern Adelaide has numerous natural environmental and cultural heritage assets and services including terrestrial, coastal, aquatic and marine systems which support a diverse assemblage of flora and fauna species, including threatened and migratory species and a number of threatened plant communities.

3 How will climate change affect the region?

The following section provides an overview of climate change, climate projections modelling, and climate projections relevant to the Northern Adelaide region. Further detailed information and references are available in the *Climate Change Projections for Northern Adelaide* report developed for the Adapting Northern Adelaide project (Adapting Northern Adelaide, 2015a)

3.1 Overview

Climate is the average weather over long periods of time (IPCC, 2013a). The World Meteorological Organization defines the climate as the average weather over a 30 year period. Climate change refers to altered climate trends (e.g. increasing temperatures, decreasing rainfall) as averaged over decades or longer. It differs from climate variability which refers to short-term weather fluctuations (1-10 years) (e.g. drought and non-drought cycles) which may occur despite the underlying climate trend.

Climate change is a consequence of the release of greenhouse gases like carbon dioxide, methane and nitrous oxide into the Earth's atmosphere (CSIRO and Bureau of Meteorology, 2015). These gases are produced from a range of natural sources as well as from human activities like energy production, transport, industrial processing, waste management, agriculture, and land management. Greenhouse gases trap the sun's energy in the Earth's atmosphere leading to changes in the global climate. These changes include: increasing air temperatures, changes to rainfall patterns, rising sea levels, and increasing sea surface temperatures.

The most authoritative source of information on climate change is provided by the Intergovernmental Panel on Climate Change (IPCC). Every five to six years the IPCC produces an Assessment Report which presents the most up-to-date scientific knowledge regarding climate change. The most recent of these reports is the Fifth Assessment Report (AR5), released in 2013 (IPCC, 2014). A key finding from the AR5 Synthesis Report (Summary for Policy Makers) is as follows:

> "*Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise" (IPCC 2014, p10).*

Climate change modelling results contained in these reports are used globally to underpin climate change action, including adaptation planning.

It is not possible to “predict” or “forecast” what the future climate might be. Instead, climate models use emissions and land-use scenarios to develop a range of “projections/scenarios” that can be used to explore what future climate conditions may occur. These projections contain inherent variability, which are important to understand when determining how best to use climate data in adaptation planning (Adapting Northern Adelaide, 2015a). Two of the main sources of variability in climate projections derive from the choice of global climate model/s (GCMs) and representative concentration pathway (RCP).

Global Climate Models are numerical models that explore how processes in the atmosphere, ocean, cryosphere and land surface respond to increasing greenhouse gas concentrations. GCMs are used to generate projections for climate variables like temperature and rainfall. Given the variability that exists across the projections outputs of climate modelling, communication of the outputs often use the median or 50th percentile model output (sometimes described as the “best estimate”), or the 10th and 90th percentile outputs.

Representative Concentration Pathways refer to four main scenarios presented in IPCC AR5 which consider time series of alternative emissions together with concentrations of the full suite of greenhouse gases, aerosols and chemically active gases, as well as varying land-use/land cover to produce alternative future climate conditions (IPCC, 2013b). The four main RCPs outlined in AR5 as the basis for the climate projections (IIASA, 2009) are:

- **RCP2.5 “Peak and decline scenario”** – an emissions pathway leading to very low greenhouse gas concentration levels; a so-called "peak" scenario (radiative forcing peaks at approximately 3 Watts per square metre (W/m^2) before 2100 and then declines);
- **RCP4.5 “Intermediate, stabilisation scenario”** – an emissions pathway where the impact of climate change on the atmosphere is stabilised before 2100 by using a range of technologies and strategies for reducing greenhouse gas emissions (radiative forcing stabilises at approximately 4.5 W/m^2 after 2100);
- **RCP6.0 “Intermediate, stabilisation scenario”** – an emissions pathway where the impact of climate change on the atmosphere is stabilised after 2100 by using a range of technologies and strategies for reducing greenhouse gas emissions (radiative forcing is stabilised at approximately 6.0 W/m^2 after 2100); and
- **RCP8.5 “High emissions scenario”** – an emissions pathway characterized by increasing greenhouse gas emissions over time leading to high greenhouse gas concentration levels.

For South Australia, there are two main sources of information on climate projections, which both use RCPs and GCMs presented in the IPCC's AR5 (Adapting Northern Adelaide, 2015a):

- **SA Climate-ready (SACR)[2]:** released in February 2015, this is the Goyder Institute's "Agreed downscaled climate projections for South Australia" project. The project provides regional-scale projected climate trends for the State for four timeframes (2030, 2050, 2070 and 2090), under two RCPs (RCP4.5 and RCP8.5), and for five climate variables: areal evapotranspiration; temperature; rainfall; vapour pressure deficit; and solar radiation;
- **Climate Change in Australia (CCIA)[3]:** released in February 2015, this is a national-focused CSIRO and Bureau of Meteorology project that provides future "application ready" climate data for eight GCMs. Information for the following climate variables is available: fire weather days; sea surface temperature; mean and extreme sea-level rise; sea surface salinity; ocean acidification; solar radiation; point potential evapotranspiration; temperature; rainfall; wet areal evapotranspiration; relative humidity; and wind speed.

3.2 Regional projections

Since the 1950's, South Australia has experienced nearly 1°C of warming and a reduction in average rainfall (CSIRO and Bureau of Meteorology, 2015). This warming and drying is projected to continue throughout the 21st century and will lead to changes in the environment, economy and community. To better understand what a future climate may be like in the Northern Adelaide region, climate analogues were identified using the CCIA's Climate Analogues Tool[4]. The most relevant available analogue locations for the Northern Adelaide region were Adelaide and Gawler for the timeframes of 2050 and 2090. The Climate Analogues tool suggests that Adelaide will experience a climate more similar to Gawler and Kadina by 2050 (RCP8.5) while Gawler will experience a climate more similar to Port Pirie (RCP8.5). By 2090 under a high emission pathway, Adelaide will be more similar to Cobar (NSW) and Gawler will be more similar to White Cliffs (NSW) (Adapting Northern Adelaide, 2015a).

Specific projections for climate variables used in the ANA project are shown in **Table 1** and briefly descried below, with further details available in the *Climate Change Projections for Northern Adelaide* report (Adapting Northern Adelaide, 2015a). Unless indicated otherwise, projections data is from SA Climate-ready.

[2] Further information and regional scale summaries generated from SACR can be found at: www.goyderinstitute.org or https://data.environment.sa.gov.au for access to the detailed datasets.
[3] Additional information on the project and access to projection data can be found at www.climatechangeinaustralia.gov.au.

Table 1. Climate variable projections for the Northern Adelaide Region under a high emissions pathway (RCP8.5) to 2070 (for further details see Adapting Northern Adelaide (2015)).

CLIMATE VARIABLE	PROJECTED CHANGE BY 2070
Rainfall - annual median - declining	11%
Rainfall - summer median - declining	7.5%
Rainfall - autumn median - declining	11.6%
Rainfall - winter median - declining	7.6%
Rainfall - spring median - declining	20.6%
Rainfall - intensity - increasing	16%
Temperature - annual median maximum - increasing	2.3ºC
Temperature - summer median maximum - increasing	2.1ºC
Temperature - autumn median maximum - increasing	2.3ºC
Temperature - winter median maximum - increasing	2.2ºC
Temperature - spring median maximum - increasing	2.9ºC
Temperature - annual median minimum - increasing	2.0ºC
Temperature - summer median minimum - increasing	1.9ºC
Temperature - autumn median minimum - increasing	2.3ºC
Temperature - winter median minimum - increasing	1.8ºC
Temperature - spring median minimum - increasing	2.2ºC
Temperature - annual number of days above 35ºC - increasing	Adelaide: 31 days (82% increase) Gawler: 44 days (76% increase)
Temperature - annual number of days above 40ºC - increasing	Adelaide: 8.5 days (325% increase) Gawler: 14 days (180% increase)
Fire - annual number of severe fire risk days - increasing	135% *
Sea level - increasing	41 cm
Temperature - sea surface - increasing	2.2ºC *
Ocean acidity - increasing	0.32 reduction in pH *

* Projection for 2090 rather than 2070 based on availability of data.

3.2.1 Rainfall

By 2050, the annual median rainfall is projected to decline by 6.8% and 7.4% compared with the baseline (1986-2005) under the intermediate and high emissions pathways, respectively. By 2070, projected rainfall decline under the intermediate emissions pathway is 5.7%, compared to 11% under the high emissions pathway. Under 2070 projections, for example, Salisbury's current annual average rainfall of 458mm would decline to 431mm under the intermediate emissions pathway and 408mm under the high emissions pathway

Seasonal differences in average rainfall are also projected for the region. Similar trends occur in 2050 as in 2070, with median spring rainfall projected to decline by 16.4% under the intermediate emissions pathway compared with 3.2-9.6% for other seasons. For the high emissions pathway in 2070, the spring decline is 20.6% compared to 7.5-11.6% for other seasons.

3.2.2 Rainfall intensity

According to the CCIA project, there is high confidence that the intensity of heavy rainfall events (maximum 1-day rainfall) will increase in the Northern Adelaide region, despite projected decreases in mean rainfall. The CCIA does not provide quantitative modelling for rainfall intensity. However, for the purposes of obtaining regional projections, other recent analyses outside of SACR and CCIA have been drawn upon to project increases in rainfall intensity in the region by 9% and 11% by 2050 under an intermediate and high emissions pathway, respectively, and at least 11% and 16% by 2070.

3.2.3 Maximum temperature

By 2050, the annual median maximum temperature in the region is projected to increase (compared to the baseline) by 1.3ºC and 1.6 ºC under the intermediate and high emissions pathways, respectively. By 2070, the projected increases in maximum temperature are 1.5ºC for the intermediate emissions pathway and 2.3 ºC for the high emissions pathway.

In the Northern Adelaide region this means that by 2070 the annual median maximum temperatures at Parafield Airport, for example, could increase from the current 22.6ºC to 24.1ºC or 24.9ºC under intermediate or high emissions pathways (respectively). It is also anticipated that daily maximum temperatures will rise, noting that the region has already experienced temperatures above 45ºC in the past.

Maximum temperatures vary across seasons, particularly for spring. Similar trends occur in 2050 as in 2070, with summer, autumn, and winter median maximum temperatures projected to increase by 1.3-1.5ºC under an intermediate emissions pathway compared with 1.9ºC in spring. Under a high emissions pathway summer, autumn, and winter increase by 2.1-2.3ºC, and spring by 2.9ºC.

3.2.4 Minimum temperature

Annual median minimum temperatures show a similar trend to maximums, suggesting an increase by 2050 of 1.0ºC and 1.3 ºC under the intermediate and high emissions pathways, respectively. By 2070, the projected increase in minimum temperatures under an intermediate emissions pathway is 1.2ºC compared with 2.0ºC under a high emissions pathway.

The difference in projected median minimum temperatures across seasons is generally minimal. By 2070, the range of change increases slightly under the intermediate emissions pathway to 1.0-1.2ºC. It is only under the high emissions pathway for 2070 that the seasonal differences are more pronounced, with winter and summer increases of 1.8 and 1.9ºC, compared with 2.2 and 2.3ºC for spring and autumn.

3.2.5 Heat extremes

The Northern Adelaide region is likely to experience an increase in extreme heat (i.e. number of days over 35ºC or 40ºC) in the future[4]. However, specific projections of changes in extreme heat using CCIA results are available for Adelaide and Gawler, but not specific locations within the Cities of Playford or Salisbury.

In Adelaide, by 2050 the number of days over 35ºC is projected to increase from 17 per year to 23 or 27 per year under intermediate or high emissions pathways, respectively. By 2070, under the same emissions pathways, the number of days over 35 ºC is projected to increase to 25.5 or 31 per year. A greater increase occurs for the number of days over 40ºC, with at least a doubling by 2050 under intermediate and high emissions, and an increase from 2 days per year to 5.5 or 8.5 by 2070.

In Gawler, the number of days over 40ºC will increase from the current 5 days to 8.5 or 10.5 in 2050 and 10.5 or 14 in 2070, under an intermediate or high emissions pathway, respectively.

3.2.6 Fire weather

Fire weather projections were estimated in the CCIA project using the McArthur Forest Fire Danger Index (FFDI), which is a widely used measure to forecast the influence of weather on fire behaviour (Hope, et al., 2015).

Fire weather is considered ‘severe’ when FFDI exceeds 50 and ‘extreme’ when FFDI exceeds 75. The CCIA project generated FFDI projections for four weather stations in South

[4] Extreme heat measures differ from heatwave conditions, with extreme heat being based on total number of days above a thermal threshold, whereas heatwave conditions have more specific definitions, such as “three or more consecutive days with the average of the daily maximum and minimum exceeding 32ºC”.

Australia, of which Adelaide is the most relevant to the Northern Adelaide region. The other locations in the State are Ceduna, Woomera, and Mt Gambier. FFDI was calculated at Adelaide by Hope et al. (2015) for only two future timeframes (2030 and 2090).

The FFDI projections indicate increased fire weather in the future for Adelaide. General fire weather danger is projected to increase by 2030 by 6% or 13% under intermediate or high emissions pathways, and by 12% or 29% by 2090.

There are also a number of factors that compound bushfire risk:

- longer dry periods leading into and throughout the fire danger season are likely to cause drier vegetation creating additional risk on severe fire danger days; and
- extreme years may occur during El Nino cycles (coupled with complex interactions of the Indian Ocean Dipole and Southern Oscillation Index) and are likely to result in some fire danger seasons being more intense compared with the change in the average fire weather danger. (REF)

Further efforts to analyse apparent changes in fire weather severity in southern Australia over recent decades and to apply future emissions scenarios are being investigated by the CSIRO and BOM.

Note that the weather metrics differ and fuel loads (linked to wild fire risk) are substantially lower in Adelaide, compared to the Northern Adelaide region. As such, although the Adelaide-based projections are the most relevant available for the region at the time of this report, they likely underestimate the number of fire risk days within much of the Northern Adelaide region, particularly in the hills and hills face zones.

Annual rainfall in the Northern Adelaide region is projected to decline by 2070, and annual maximum and minimum temperatures will increase.

3.2.7 Ocean and Gulf waters

For Ocean and Gulf waters, under a high emissions pathway, projections suggest a:

- rise in sea levels of 41cm by 2070 and 61cm by 2090;
- rise in sea surface temperatures of 2.2ºC by 2090; and
- decline of 0.32pH units by 2090.

Ocean and gulf waters will increase in temperature, pH will decline and sea levels will rise.

4 How has this plan been developed?

4.1 Approach

This Adaptation Plan has been developed in three phases and has involved the active participation of the region's project partners as well as key stakeholders and subject matter experts in order to provide a strong foundation for adaptation (**Figure 2**).

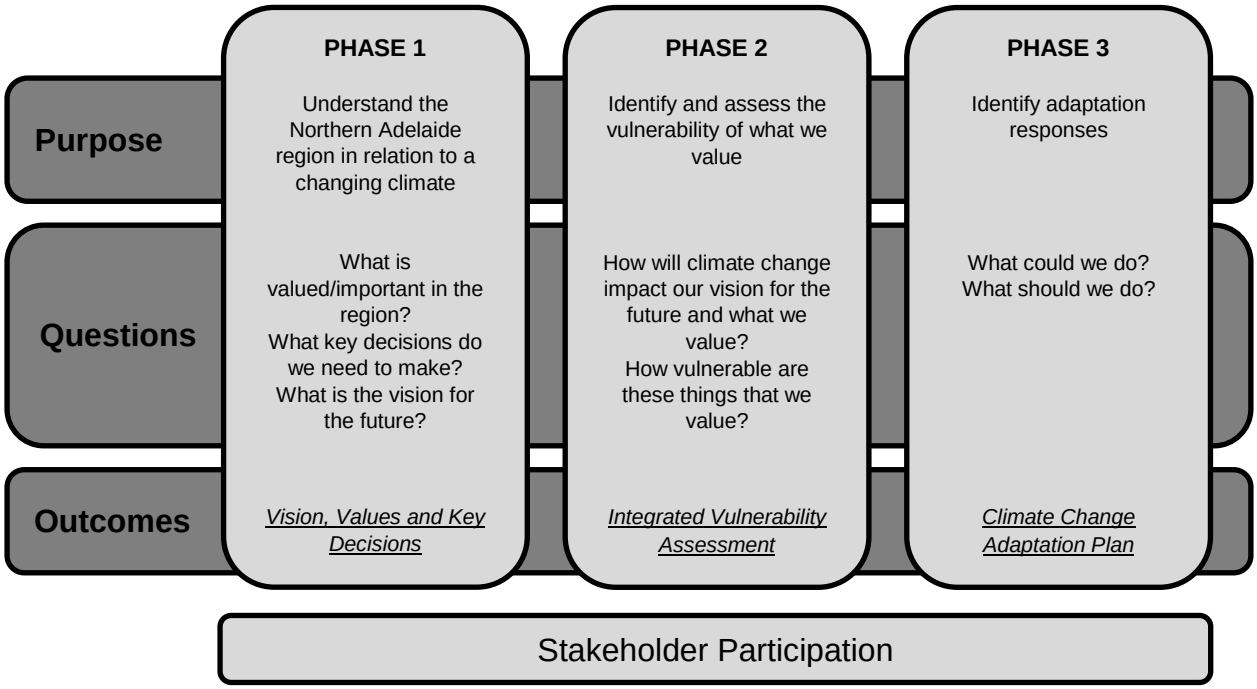

Figure 2. Overview of key steps undertaken to develop the Adapting Northern Adelaide Plan.

Project partners, with input from community, business, government, industry and academia, completed the initial phase in 2015, which included three main steps:

- development of the *Regional Profile for Northern Adelaide* report which describes the composite social, economic and environmental features of the whole region (Adapting Northern Adelaide, 2015b);
- values mapping and strategic impact areas workshops to identify stakeholder issues and values in relation to climate change adaptation in the region (Adapting Northern Adelaide, 2015c); and

- development of *Climate Change Projections for Northern Adelaide* report which provides up-to-date information regarding climate change modelling, best science and projections for the whole region (Adapting Northern Adelaide, 2015a);

The second phase involved an Integrated Vulnerability Assessment for the Northern Adelaide region, which identified sectors and systems most likely to be vulnerable to the impacts of climate change (Adapting Northern Adelaide, 2015d).

The final phase of the project involved a series of subject matter expert and local stakeholder workshops, which used an adaptation pathways approach to identify adaptation options. A description of how to interpret adaptation pathways maps, which are presented for each key area of decision making in Section 5, is provided in Attachment A.

Attachment B lists stakeholders who attended the project workshops or focus groups or played a key role in providing input to the development of this Plan and associated reports.

4.2 Identifying priorities for adaptation planning

Values mapping conducted as part of Phase 1, identified seven core values of importance to stakeholders in the region in the context of projected climate change impacts (Adapting Northern Adelaide, 2015c):

- liveable communities;
- active and healthy lifestyles;
- educated and skilled workforce;
- prosperous and vibrant local economy;
- infrastructure for the economy and community;
- sustainable water management and water security; and
- sustainable and resilient natural environments.

These core values were shown to align with three themes and 10 strategic sectors (**Table 2**).

Based on the strategic sectors a number of indicators were selected to underpin the integrated vulnerability assessment (IVA) conducted in Phase 2 (Adapting Northern Adelaide, 2015d). The IVA assessed a total of 63 indicators and was undertaken consistent with the approach described in the Local Government Association of South Australia's *Guidelines for Developing a Climate Change Adaptation Plan and Integrated Climate Change Vulnerability Assessment* (Local Government Association of South Australia, 2012). High vulnerability indicators identified from the IVA are presented in Attachment C.

Table 2. Themes and strategic sectors.

THEME	STRATEGIC SECTOR
Theme 1: Changing environment	• Marine and coastal management • Terrestrial biodiversity • Water management • Public open space
Theme 2: Community living	• Health and community vulnerability, capacity and resources • Emergency management preparedness for, and response to, extreme events
Theme 3: Economy and development	• Assets and infrastructure • Urban planning and development • Primary production and premium food • Clean tech industries

Based on the results of the IVA together with consideration of emerging opportunities, key areas of decision making were developed as the basis for further adaptation planning. Key areas of decision making describe:

- what is important for a region, making a connection between something of value or importance to stakeholders such as an asset or service;
- what responses are possible; and
- how important aspects might be impacted by climate change.

The key areas of decision making that form the focus of this Adaptation Plan are presented in **Table 3**. An infographic that also shows the key areas of decision making in a pictorial form and that was used during stakeholder workshops is shown in **Figure 3**.

Adaptation options for each key area of decision making were identified by the project team and then reviewed and refined by key stakeholders and subject matter experts at a series of project workshops. To assist with prioritisation, workshop participants were asked to conduct a qualitative cost-benefit analysis on proposed adaptation options. Further prioritisation was conducted by the project steering committee using a prioritisation framework. The framework applied a three-step filtering process based on the results of the costs-benefit analysis, an assessment of the regional relevance of an option (relevance to multiple key areas of decision making and multiple project partners), and practicality (availability of funding and project partner role in delivery).

Table 3. Key areas of decision making for the Adapting Northern Adelaide region.

SECTOR	KEY AREA OF DECISION MAKING
Health and safety of vulnerable people	How do we maintain and enhance the health, safety and wellbeing of vulnerable members of the community as the risk of extreme events such as heat waves and fire risk increases?
Horticulture – Northern Adelaide Food Bowl	How do we maintain the productivity of horticulture in the region as the climate becomes warmer and drier and the risk of extreme climatic events increases?
Water dependent ecosystems – riparian zones and natural wetlands	How do we maintain and build the resilience of natural wetlands and riparian zone communities along natural watercourses as the climate becomes warmer and drier?
Water dependent ecosystems – constructed wetlands	How do we maintain the condition and function of constructed wetlands dependent on surface water flows as rainfall quantity declines and intensity increases?
Coastal ecosystems	How do we maintain the condition and extent of natural coastal and estuarine landscapes and near shore marine environments as sea level rises, rainfall intensity increases and ocean acidity declines?
Natural landscapes – hills and hillsface	How do we maintain the condition and extent of natural landscapes (hills) as the climate becomes warmer and drier and the risk of fire increases?
Natural landscapes – plains	How do we maintain the condition and extent of natural landscapes across the Northern Adelaide Plains as the climate becomes warmer and drier and the risk of fire increases?
Extreme events and emergency management	How do we meet the increasing demand for emergency services as the risk of extreme climatic events increases, such as fire, heat waves and flood risk?
Public open space and recreation	How do we maintain and enhance the condition of open space and public realm as conditions become warmer and drier and the risk of climatic extreme increases?
Climate-ready buildings	How do we construct and maintain climate ready residential, commercial and industrial buildings as the risk of extreme climatic events increases?
Adaptive economy	How do we develop business and industry and tourism in the region in a way that is adapted to local climatic conditions but connects with emerging opportunities?

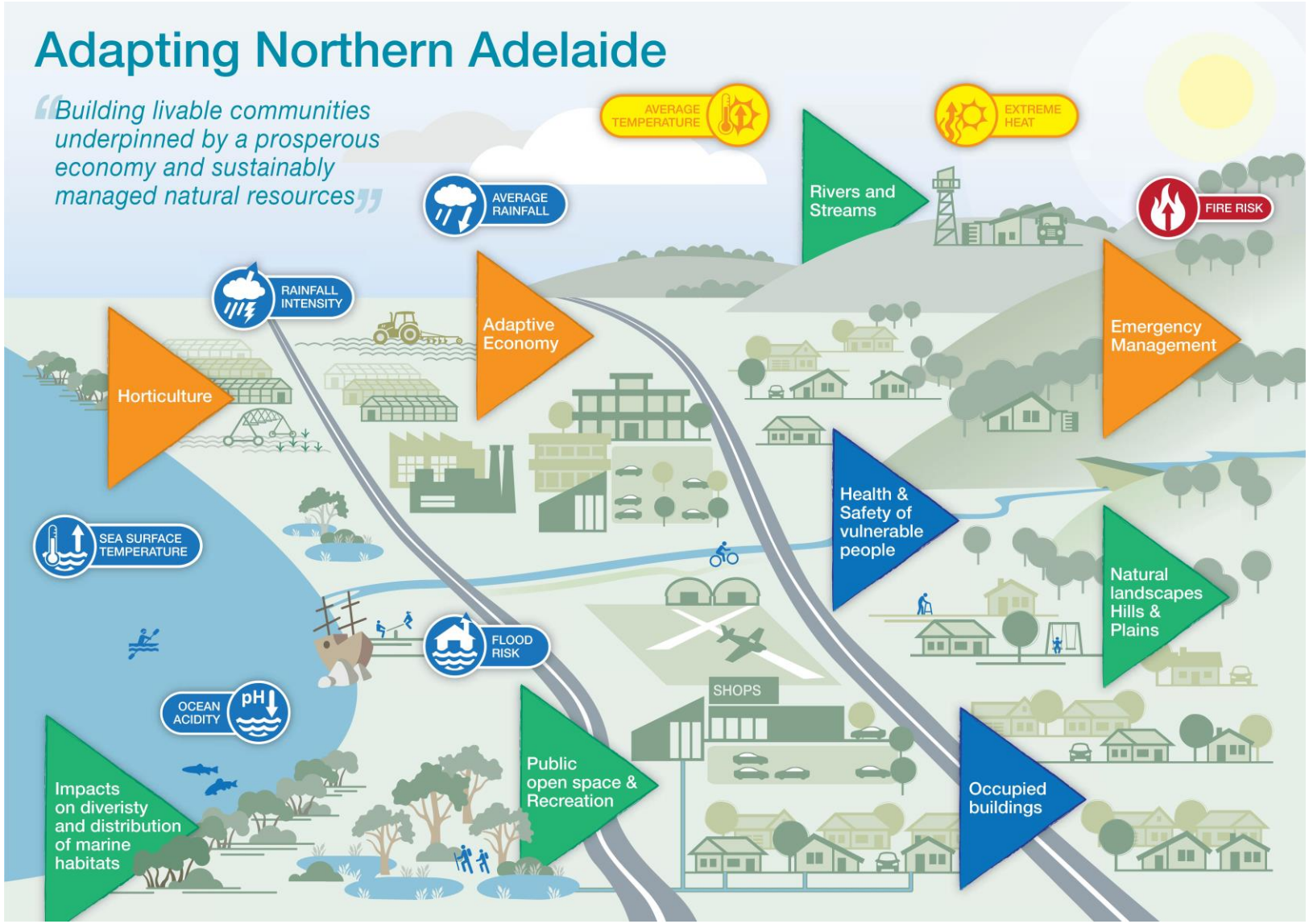

Figure 3. Infographic showing key area of decision making themes for the Adapting Northern Adelaide project.

5 Priority adaptation options

5.1 Adaptive economy

Key area of decision-making

How do we develop business and industry and tourism in the region in a way that is adapted to local climatic conditions but connects with emerging opportunities?

Northern Adelaide is a major contributor to the economic activity of the State for decades. The region employs over 78,000 people, with approximately 50,000 in the City of Salisbury and over 28,000 in the City of Playford, representing approximately 12% of the State's workforce (Adapting Northern Adelaide, 2015b). Combined, the two council areas have a Gross Regional Product of $8.12 billion, representing about 8.9% of the State's economy. The greatest employers in the region are manufacturing (16.5% of people employed in the region, compared with 10.5% for the entire State), retail trade and health care and social assistance (12%).

The imminent closure of auto-manufacturing has prompted a number of initiatives to explore how to diversify the economy of the Northern Adelaide region. Future economic development is expected to be built around:

- food production and processing;
- growth in healthcare, aged care and associated infrastructure and construction;
- defence and aerospace;
- research, education and training;
- manufacturing skills and expertise intrinsic to the success of the defence, food and wine, and other sectors in the region; and
- distribution and logistics

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), without adaptation the region's economic base is vulnerable to changing climatic conditions, such as extreme heat and warmer and drier conditions. Extreme heat will influence working conditions, especially in industries and businesses that involve substantial periods of work outdoors. Even for those people working indoors, extreme heat will require investment to ensure that working conditions remain safe. Warmer and drier conditions will be especially important for those business involved with on- and off-farm food production.

Despite the vulnerability of the region's economy to climate change, there are also likely to be emerging opportunities with some businesses providing services that could be in greater demand in the future as consumers and governments seek out new goods and services for climate adaptation and mitigation. Northern Adelaide is well positioned to take advantage of such emerging opportunities as its economy transitions.

Priority adaptation options

The focus of economic development in Northern Adelaide in response to climate change will be to develop an adaptive economy. This will be sensitive to the impacts of climate change, and how local solutions can align with emerging domestic and international market opportunities for adaptation and mitigation.

An immediate adaptation priority for completion within the coming five years will be to **support businesses to achieve efficient resource use** and implement a series of **risk and opportunity assessments to inform investment prioritisation** (**Figure 4**). Risk and opportunity assessments will require input from a broad range of stakeholders, as well as: engagement with key representative bodies in the community, agreement on the parameters of the assessment, an ability to showcase existing best practice, identification of leaders, and demonstration of "lighthouse" projects.

Also for immediate implementation, but completion within 10 years, is an **improvement of branding and promotion of Northern Adelaide green industries, products and services**, and establishment (if not already in place) of **backup power and generators for key infrastructure (such as for stormwater pump out systems) and vulnerable businesses**. A focus on supporting green industries is a major initiative that will underpin implementation of this Plan.

Branding and promotion of Northern Adelaide green industries, products and services will require the development of demonstration sites, identifying suitable certification programs, development of the "Adelaide Plains" Food Bowl concept, and developing a brand with an international export focus.

An immediate priority that will require ongoing implementation is to **attract businesses that will benefit from the region's sustainable resource management practices**. For example, this could include businesses in the food production sector that want to benefit from the region's high profile with respect to sustainable water management practices.

While much of the initial focus of the adaptive economy theme is to encourage new business to establish in the region, an increasing emphasis will need to be placed on **adapting manufacturing and food production for projected climate change**. This will mean ensuring that risk mitigation and resilient buildings strategies are in place to support industry.

Within 10 years, an **increase in investment in protected cropping for improved food production** will be required. This aligns strongly with the objectives of the horticulture sector and can be supported by the anticipated expansion of the Bolivar DAFF plant, which will supply up to an additional 20GL of recycled water for use in the region.

A cluster management approach could be applied to a range of initiatives under the adaptive economy theme, seeking to optimise the links between businesses, universities (research development), all levels of government and customers.

Triggers

A large number of triggers exist that could stimulate increased implementation of options to support development of an adaptive economy. The most important triggers identified are:

- the provision of investment by SA Water in recycled water infrastructure at the Bolivar DAFF;
- the Northern Connector and proposal for housing development on reclaimed salt crystalisation ponds, which will and must incorporate systems to cope with storm surge events, barrier creation (the Connector), and maintaining stormwater flow;
- sea level rise thresholds being exceeded to the extent that transport operations become negatively affected, impacting the ability of the region to export freight through Port Adelaide; and
- change in community demands and consumer trends.

Other triggers could include:

- energy affordability for businesses and residents;
- changes to the cost-benefit ratio of energy storage solutions;
- changes in the electricity tariff structure;
- groundwater levels and soil salinity levels as they relate to crop viability;
- free trade agreements;
- any flooding and storm surge events which may exceed design capability leading to loss or damage to people, property and business continuity in low lying areas such as near waterways, at St Kilda, Globe Derby and in new developments such as at the salt crystalisation ponds;
- unemployment levels; and
- government regulation and incentives.

Enablers and barriers to adaptation

A major enabler for economic development in the region is the extensive experience in sustainable water management including wetlands creation, wastewater recycling (including the Virginia Pipeline Scheme), stormwater harvesting, storage and recovery projects. These

multiple sources of water provide benefits to Northern Adelaide (e.g. for industry, open space irrigation and horticulture) and have already built resilience to climate change.

Significant improvements in waste management and recycling schemes are providing new business and employment opportunities in transforming what was previously discarded to landfill, into new products and resources.
Partnerships and collaboration between businesses, local government business attraction teams, the state Government and the University and research sectors is a key strength of Northern Adelaide. The Region has an inspiring business culture which can be observed during the well attended monthly business breakfasts and through the work of the Northern Economic Leaders which continuously strengthen networks to maximise opportunities.

The State and Federal Government also play a crucial role in policies and programs that facilitate economic transition, and in providing financial incentives and innovation grants. The creation of Green Industries SA and Low Carbon Economy Group and renewables SA are examples of State Government support for an adaptive economy.

Other enablers to economic adaptation include:

- being recognised as the “food bowl of the north” which greatly facilitates the region’s capacity to develop business, industry and tourism adaptive to climate change;
- advanced manufacturing capacity of businesses in the region, which are already supporting the transition to a low carbon economy; and
- capacity in the region to produce components and systems for renewable energy and energy efficiency with demand expected to continue in Australia with further demand for energy efficiency and renewable energy solutions.

There are a number of barriers to the economic adaptive capacity of the region to climate change. Primarily this stems from land-use and water-use practices based on long-held farming traditions, perceived water use rights, and knowledge and perceptions of climate change impacts. Other barriers include: economic challenges and related high level of unemployment which impact on civic pride and public perceptions of certain urban centres, the sub-division and residential development of farming land, and a lack of continuous collaborative action by local, State and federal governments.

Key points

Developing and maintaining an adaptive economy in the region will require risk and opportunity assessments to inform prioritisation, and establishment and/or maintenance of backup power and generators for key infrastructure and vulnerable businesses. Adaptation will also be facilitated by attracting businesses that will benefit from the region's sustainable resources management practices. This may be achieved in part through improving the networking, branding and promotion of Northern Adelaide green industries, products and services, adapting manufacturing and food production for projected climate change, and increasing investment in protected cropping for food production.

A cluster management approach could be applied to a range of initiatives under the adaptive economy theme, seeking to optimise the links between businesses, universities (research development), all levels of government and customers.

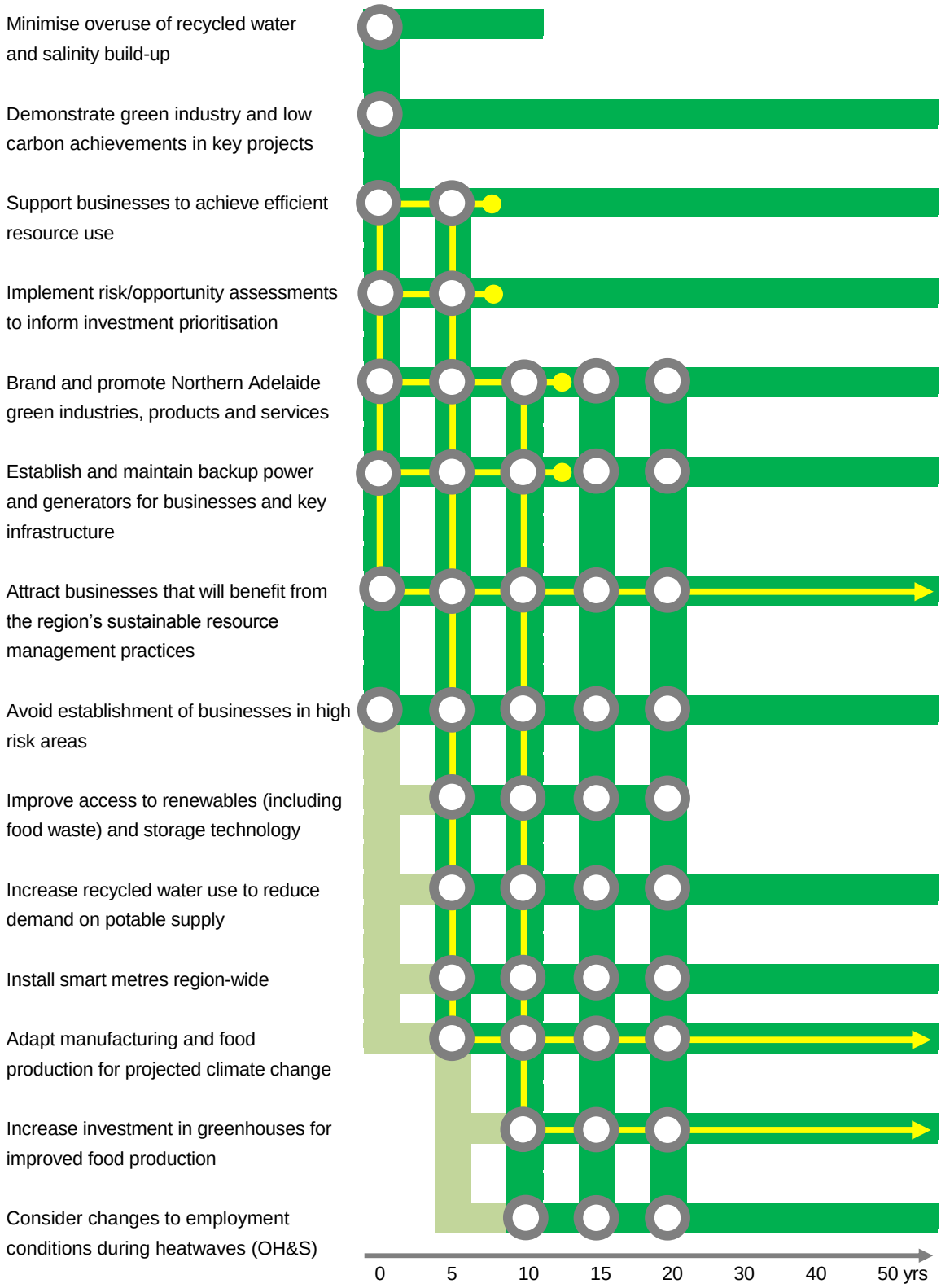

Figure 4. Adaptation pathway for development of an adaptive economy in Northern Adelaide.

5.2 Climate-ready buildings

Key area of decision-making

How do we construct and maintain climate-ready residential, commercial and industrial buildings as the risk of extreme climatic events increases?

Northern Adelaide is highly valued as a place to live and work, with the creation of liveable communities important for residents in the City of Salisbury and City of Playford (Adapting Northern Adelaide, 2015b). Liveable communities require access to open space, natural environments, green infrastructure and clean air, water, and soil along with safe, sustainable, adaptable and affordable housing and public buildings (e.g. community centres and libraries).

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), climate-change driven increases in extreme events (i.e. floods, bushfire, heatwaves) will have significant impacts on buildings in the region. For example, bushfires will lead to direct damage of infrastructure – as demonstrated during the 2015 Sampson Flat bushfires – and heatwaves can lead to soil heavage (cracking) disrupting the footings for buildings.

Priority adaptation options

A range of adaptation options have been identified for immediate implementation (**Figure 5**) that collectively will encourage homeowners and the development industry to increase the number of climate-ready homes and buildings in the region. This will contribute to the creation of more liveable communities and potentially reduced costs of living. These adaptation options are:

- **collaborating with the housing sector** on low carbon, sustainable urbanisation initiatives and partnerships;
- **providing incentives** for increased construction of climate-ready buildings;
- **identifying barriers** to implementing climate-ready housing under the existing provisions of the building code;
- **raising awareness** about the benefits of climate-ready buildings and urban environments; and
- **preparing guidelines** on how to encourage greater use of climate-ready building techniques, site development, and master planning.

Two of the options listed above were considered in more detail with respect to how to achieve implementation. Raising awareness about the benefits of climate-ready buildings will

require information on the business-case for changes to design and buildings practices and a strategy on how to communicate this information to a mainstream audience. On the other hand, preparing guidelines on how to encourage greater use of climate-ready building techniques will need to adopt a multidisciplinary approach involving educators, developers, landscape architects, engineers and planners. There are also strong linkages between the creation of climate ready buildings and developments for occupants, with economic opportunities for local businesses in demonstrating excellence that can be promoted in growing national and international markets.

Within five years, **amendments to the Building Code of Australia** should be proposed that lead to **strengthening and mandating building requirements in new developments**.

Development Plan amendments should incorporate up to date information to have regard for flooding and fire exposure to ensure appropriate placement of developments that are able to cope with climate risks.

While not a priority option for immediate implementation, within two decades it is anticipated that some existing homes and infrastructure will need to be considered for relocation due to being in areas at high risk of impact from bushfire and flooding. Although the timing of implementation for this option is delayed, preparatory work is required now to better understand where such homes and infrastructure are located.

Triggers

A wide range of triggers exist that could lead to greater implementation of options to create more climate-ready housing. The most important triggers are considered to be the:

- cost of energy and water; and
- community awareness and political advocacy leading to greater demand for climate-ready buildings.

Other triggers could include:

- in-fill development and reduced amenity leading to greater urban heat island impacts;
- increases in physical and mental health issues and costs;
- occupational health and safety issues arising from poorly designed and constructed buildings;
- improved marketability and reputation for businesses (nationally and internationally); and
- funding, incentives and partnerships.

While climate-ready developments promise much in terms of improved living and working conditions, monitoring and evaluation will be required to determine whether climate-ready developments achieve desired outcomes relative to other conventional developments.

Enablers and barriers to adaptation

The Northern Adelaide community has already experienced extreme heatwave events which means the community understands the nature of the risk and so may provide community support for constructing and maintaining climate-ready buildings. Existing scientific knowledge, innovative manufactured solutions, and ready access to various solutions will further help adaptation.

However, there is a mismatch between experience and valuing approaches that will assist with adaptation. For example, despite the impact of extreme heat waves, some residents in the region are likely to oppose (locally or generally) increasing the number of trees and associated green infrastructure that would help cool buildings. This may be compounded by perceptions of cost and maintenance.

Key points

Priority adaptation options for climate-ready buildings are to: collaborate with the housing sector on low carbon sustainable urbanisation initiatives and partnerships; provide incentives for increased construction of climate-ready buildings; identify barriers to implementing suitable climate-ready housing under the existing provisions of the building code; and, prepare guidelines on how to encourage greater use of climate-ready building techniques, site development, and master planning. These options should be implemented now and over the next 5-10years.

Planning will also need to commence now in order to propose amendments to the Building Code of Australia and to inform development plan amendments within five years to strengthen and mandate building requirements in new developments.

In the future, adaptation may also need to consider relocating infrastructure and housing currently occurring in high risk areas where there is limited capacity to adapt or excessive cost to ensure safety. Although this may not be implemented for 20 years, planning should start now.

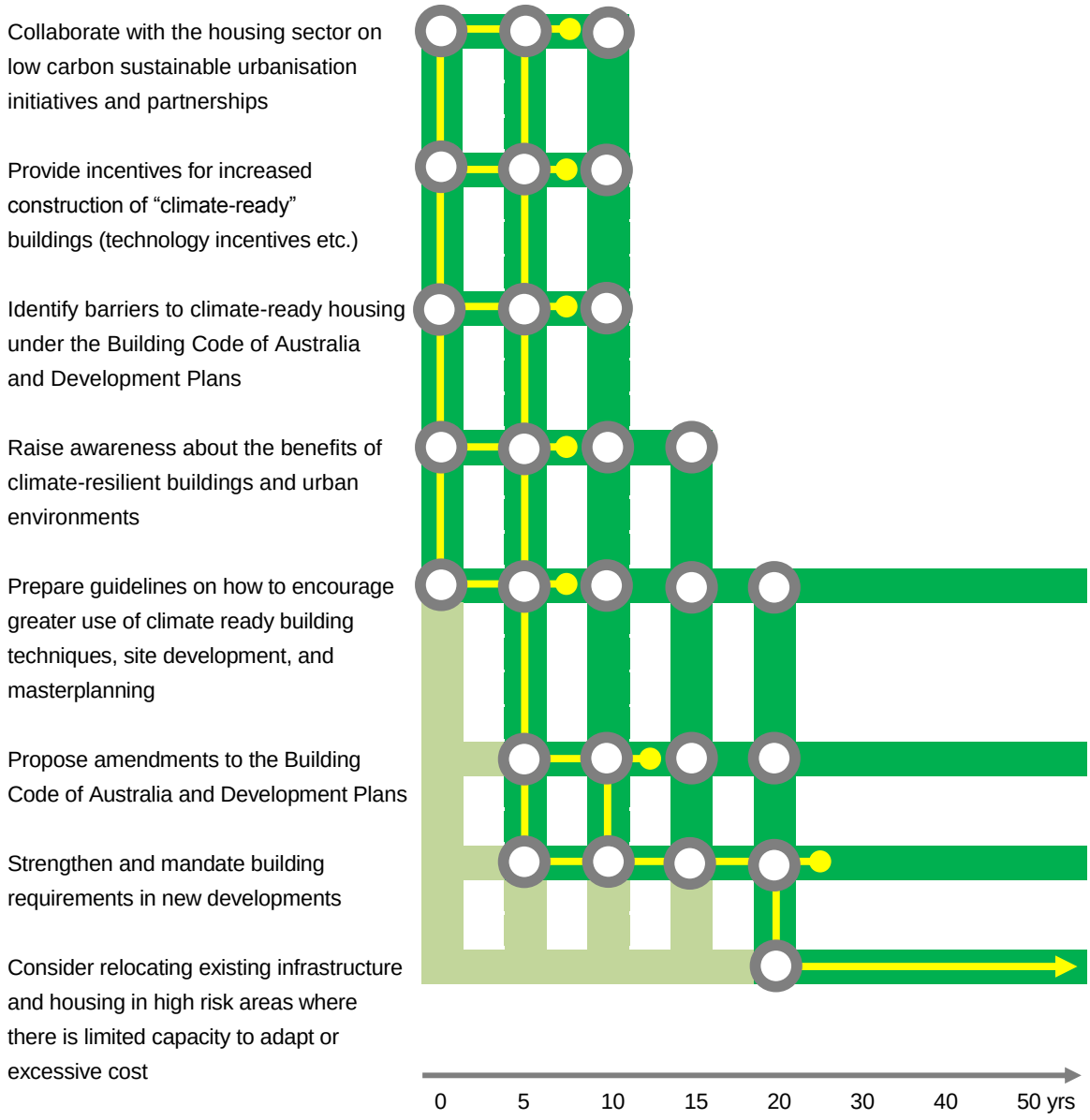

Figure 5. Adaptation pathway for climate-ready buildings in Northern Adelaide.

5.3 Coastal ecosystems

Key area of decision-making

How do we maintain the condition and extent of natural coastal and estuarine landscapes and near shore marine environments as sea level rises, rainfall intensity increases and ocean acidity declines?

The region's 24km of coastline extends from the Barker Inlet Estuary in the south to the Port Gawler Conservation Park in the north. It is regionally significant due to its recognised function as an estuary and its diversity of habitat types as follows:

- **Intertidal mudflats** (Mudflat area = 7.2 km2) (Source: National Land and Water Resources Audit) - Mudflats are home to a range of invertebrate species such as polychaete worms, amphipods, molluscs and crustaceans. The tidal cycle also increases the use of the mudflats by other animals (e.g. crabs) and provides feeding sites for migratory shorebirds;

- **Mangrove communities** (Area = 7.7km2) (Source: National Land and Water Resources Audit) - Only one species of mangrove (*Avicennia marina*) is represented in South Australia. The Barker Inlet Port Estuary has the most extensive area of mangroves in the region, which provides important nursery areas for recreationally and commercially significant fish. There are no mangroves extending south of the Barker Inlet Port Estuary;

- **Saltmarshes** (Area = 6.3 km2) (Source: National Land and Water Resources Audit) - Within the Natural Resources Adelaide and Mount Lofty Ranges region, the Gawler River, Barker Inlet Port Estuary and Onkaparinga River estuaries are the only estuaries to have extensive areas of saltmarsh habitat. The saltmarshes within the Barker Inlet Port Estuary comprise 13% of the estuary area (Baker 2004). Projected sea level rise resulting from climate change will likely cause habitat retreat and have secondary impacts on fish and many other species dependent on saltmarsh habitat for survival; and

- **Seagrass communities** - Seagrass beds are located offshore from the Barker Inlet Port Estuary. Seagrass species colonising the area include tapeweed and eelgrass.

The Barker Inlet Port Estuary has been described as the most significant crustacean nursery and feeding area in Gulf St Vincent (Baker 2004). Other species of invertebrates that have been recorded in the Barker Inlet Port Estuary and the Gawler River estuary include the southern calamari, sand crab, blue swimmer crab, razorfish and scallops. The Barker Inlet Port Estuary is also a major nursery area for King George whiting, yellow-fin whiting,

southern sea garfish, yellow-eyed mullet, jumping mullet and black bream. The Estuary provides areas of particular importance for migratory and threatened bird species and is used for regular breeding of several species of colonial nesting waterbirds. Some of the nesting colonies are significant at state, national and international levels.

These coastal habitats will provide a major natural barrier to the impacts of sea level rise on adjacent built infrastructure for the planning horizon of this plan to 2070. Risks associated with sea level rise for even longer timeframes will need to be considered using an Adaptation Pathways process.

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), coastal ecosystems will be most influenced by increasing sea level, ambient and ocean temperatures, rainfall intensity, and ocean acidity; though the specific impacts of ocean acidity are less well understood.

As sea level rises the natural response of mangrove forests and samphire shrubland will be to move inland to higher elevations. Unlike many other coastal ecosystems in metropolitan Adelaide, the areas of land immediately to the west of Port Wakefield Road which lack development or hard structural barriers will present an opportunity for some landward migration (and hence adaptive capacity) of these systems.

Priority adaptation options

The swathe of mangroves and saltmarshes that lie to the west of Port Wakefield Road provide a natural barrier to the impacts of sea level rise. Protecting coastal ecosystems is therefore a major social and economic, as well as environmental, adaptation priority for the region (**Figure 5**).

An immediate priority is to continue with **modelling and mapping of coastal areas** to assist with risk management (**Figure 6**). It is expected that this will be an ongoing task requiring support from the Coast Protection Board (DEWNR) working together with councils.

Continued **restoration of coastal and marine habitats** is also required, covering areas of samphire and mangroves in the intertidal zone and sea grass in the near-shore marine environment. Within five years though, greater emphasis will be needed on **identifying, managing and restoring refugia and connectivity to support migration and range shifts** including facilitating intertidal zone landward movement of samphire and mangroves. One of the first steps in supporting this transition will be for DEWNR to investigate a Coastal Retreat Plan with councils, which will spatially identify the potential areas for samphire and mudflat retreat and restoration. Partnerships with the fishing industry and recreational fishers should be should also be explored as these coastal users can observe changes and contribute to adaptation solutions.

Maintaining hard structural barriers in the coastal zone will continue to be important for preserving social and economic values. In the immediate short term this will focus on reviewing, maintaining and inspecting hard structural barriers. However, with projected increases in sea level it is expected that within 30 years **upgrades to hard structural barriers** and related pump out infrastructure in the region will be needed (**Figure 5**). Areas of focus may include St Kilda, Globe Derby Park and new low lying developments in reclaimed salt crystallisation ponds or west of the proposed Northern Connector.

Discussions around potential impacts and response options to sea level rise have focussed on projected sea level rise over the coming 50 years. However, sea levels will continue to rise well into the next century due to changes that have already occurred in the Earth's climate and oceans, and hence some planning may need to consider longer time horizons. Responses will also need to consider what adaptation options are implemented in the neighbouring Port River Estuary.

Triggers

The principal trigger that will influence implementation of adaptation options in the coastal zone is when protection measures for built assets start to fail or are found to no longer be suitable. This will be particularly relevant at St Kilda, which is the primary settlement along the coast in this region.

Other triggers could include:

- loss of salt marsh habitat in response to sea level rise;
- increasing number of poor water quality events in the marine environment water (e.g. harmful algal blooms, fish kills, collapse in fisheries, decline in the Barker Inlet dolphin population, odours); and
- acidification of ocean waters leading to impacts on Northern Adelaide beaches that are calcium carbonate (shell) based or impacts on shell fish exoskeletons.

Enablers and barriers to adaptation

Taking actions to maintain the condition of coastal ecosystems will be enhanced by current work to establish the Adelaide International Bird Sanctuary. Increased understanding of the potential carbon sequestration benefits of saltmarsh and mangroves could provide another incentive to protect this area.

Establishing a framework to quantify the value of ecosystem services that the coastal system provides to both the State and the northern suburbs will be integral in making good long term planning decisions. This can incorporate attributes including blue carbon, storm surge mitigation, tourism, the fishing industry and recreational value that the ecosystem provides.

A barrier to maintaining coastal ecosystems will be development pressures for housing and industrial areas given that the region is close to key port infrastructure and employment opportunities.

Another barrier is that adaptation projects may have capacity constraints, such that some coastal options may not be viable for the longer term, and should therefore trigger a new adaptation pathway towards retreat or relocation.

Key points

Facilitating adaptation of natural coastal and estuarine landscapes and near shore marine environments will require ongoing modelling and mapping to assist with risk management; restoring coastal and marine habitats; and reviewing, maintaining and inspecting hard structural barriers and associated pumping infrastructure. Within five years, identifying, valuing, managing and restoring refugia and connectivity to support migration and range shifts, including facilitating the landward shift of intertidal zones should be a primary focus. In 10 years, planning for the upgrade of hard barriers and pump out infrastructure will need to start, with implementation of upgrades likely in 30-50 years' time.

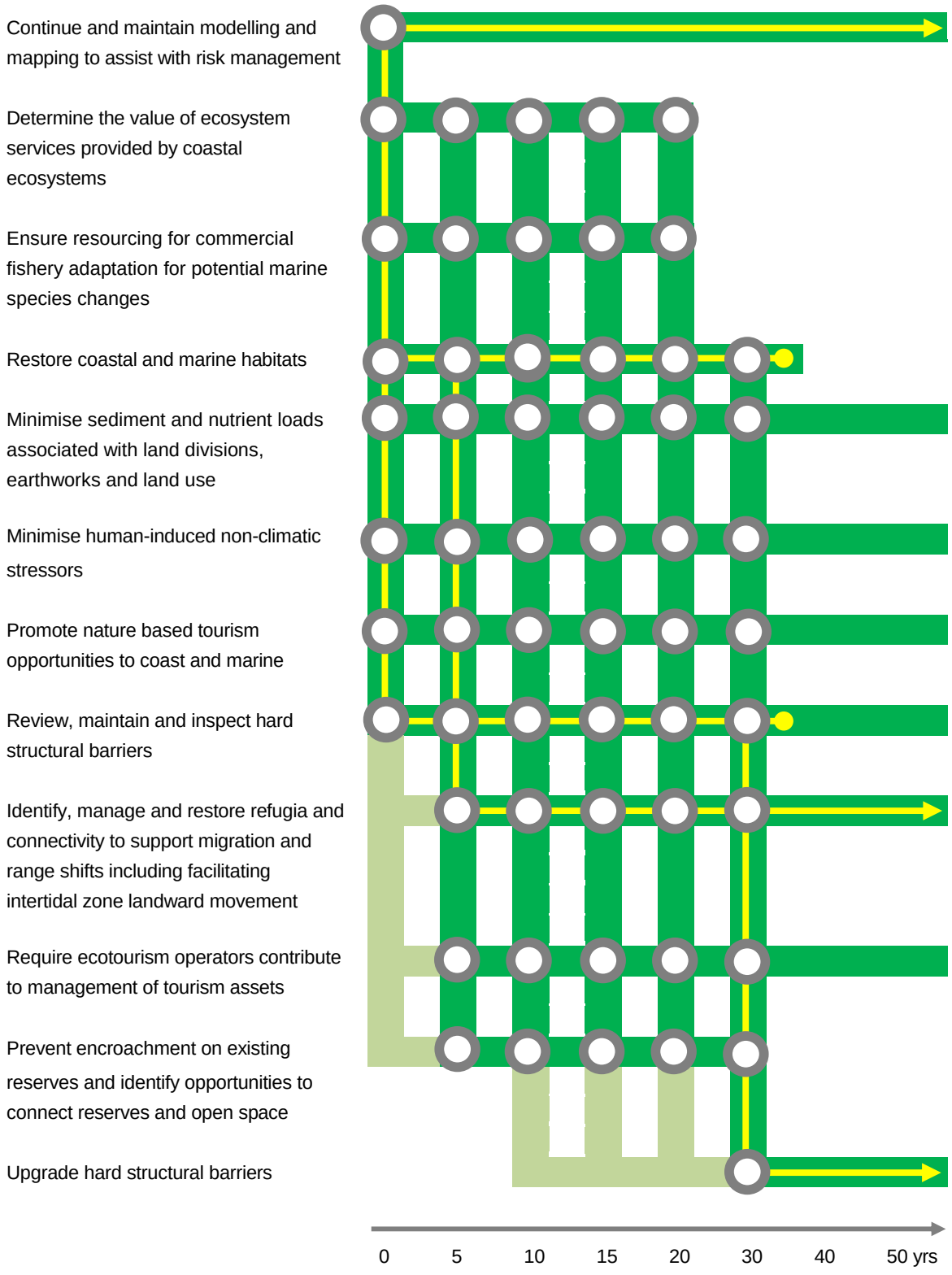

Figure 6. Adaptation pathway for maintaining the condition and extent of natural coastal and estuarine landscapes and near-shore marine environments in Northern Adelaide.

5.4 Extreme events and emergency management

Key area of decision-making

How do we meet the increasing demand for emergency services as the risk of extreme climatic events increases, such as fire, heat waves and flood risk?

Emergency management is highly valued across the region for its role in preventing, preparing for, responding to, and recovering from emergencies that threaten the health and safety of residents and the condition and functioning of buildings and infrastructure. Emergency management in Northern Adelaide is supported by:

- metropolitan fire service stations located at Elizabeth and Salisbury;
- Country Fire Services stations located at Virginia and One Tree Hill;
- SA State Emergency Service unit located at Edinburgh;
- SA Ambulance Service stations at Salisbury and Playford;
- health care services at Lyell McEwan Hospital; and
- police stations at Salisbury, Elizabeth and Blakeview.

Heat waves, bushfires and flooding have had significant impacts on communities in Northern Adelaide in the past.

Potential impacts of climate change

A projected warming and drying climate will increase the risk of bushfires and heatwaves in the region, and increasing sea level and rainfall intensity will increase the risk of floods. Based on the Integrated Vulnerability Assessment (Adapting Northern Adelaide, 2015d), the demand for emergency services is expected to increase in response to these events becoming more frequent and intense.

Factors that may also contribute to an increase in the demand for emergency services in the region, and hence exacerbate the impacts of climate change, include:

- a growing and aging population;
- pricing stress, particularly for electricity, gas and water;
- a difficult transport system dominated by North - South arterial roads can make it challenging for those with limited mobility to travel East - West to access shops and services;
- limited capacity of support services; and
- rationalisation of State Government support services in the region.

Priority adaptation options

Maintaining emergency services will be essential in the future given the cross-sectoral role they play in supporting the community and businesses. Immediate adaptation priorities for completion over the coming five years are to (**Figure 7**):

- **establish and implement early warning systems for flood and fire**, which can be achieved by supporting the development of SMS/phone based warning services that incorporate forecasts for heat waves and severe storms;
- **identify and establish monitoring systems** to inform emergency services decision-making, including emergency management planning for councils; and
- **raise awareness of the risks and impacts** of extreme events within the community.

There is also a need to ensure that review processes following extreme events are effective in identifying lessons learned and translating these into corrective and preventive actions.

Immediate adaptation priorities that will require ongoing delivery were two-fold. First, council and regional **emergency response plans should be regularly reviewed** to ensure that they are current, especially in relation to potential flooding, heatwaves, bushfire and storm surge impacts. Second, ongoing work will be required to **identify local extreme event related risks and responses**. In the short-term this will be informed by a series of risk mapping exercises including:

- infrared mapping across council areas during heatwave events to identify hotspots;
- updating rainfall and flood risk mapping to incorporate climate change figures; and
- incorporating DWENR bushfire impact/infrastructure mapping into Council planning processes.

Within five years, local and State government, along with community organisations, will need to assess the capacity of volunteer based services and where necessary identify methods for **increasing volunteerism and rates of participation in volunteer training**. Another priority option within five years is to start to **create buildings and infrastructure that are resilient to extreme events** through adoption of improved planning policy, building codes and new materials. This links strongly with the climate-ready building theme (Section 5.2) and will reduce the risk to life and property posed by extreme events. Similar initiatives are being developed elsewhere in South Australia and, where relevant, present an opportunity for cross-regional collaboration. Initiating action could be supported by trialling successful sustainable urbanisation techniques in local projects such as through demonstration sites in new or redeveloped precincts or as city centre projects.

Although not recognised as a priority, the review of development plans and zoning are essential in guiding appropriate development and identifying high-risk areas where housing should not be located. A climate overlay that identifies areas at the highest risk from fire, flood and coastal inundation could assist in the design of appropriate infrastructure and guide future Development Plan Amendments. This will also be required to inform decisions

about whether to protect or relocate people and infrastructure currently located in such areas, particularly where risks cannot be adequately managed or where the costs of ensuring safety are excessive.

Triggers

A wide range of triggers exist that could lead to greater implementation of options in support of emergency services management. The most important triggers are considered to be:

- occurrence of an emergency event or incident that attracts immediate investment in new responses or interest from the community;
- further evidence of change and its scale and cause, such as prolonged heat events; and
- stress on vulnerable members of our community.

Other triggers could include:

- when the frequency of events begins to impact upon response capacity (e.g. declining volunteer availability, volunteers being impacted financially);
- cost of protecting, mitigating or adapting exceeding the 'value' of an asset being protected;
- effective lobbying and advocacy regarding emergency management issues;
- community outrage over an event, its effects, and the response/s; and
- changes to the thresholds at which an event is declared a state/national disaster.

Enablers and barriers to adaptation

The region recognises its existing vulnerability to bushfires and extreme heat and as such there is already a high awareness amongst the community and a number of emergency management strategies are place. The Councils are actively engaged in fire preparedness, fie planning and in providing support services to the Country Fire Service and State Emergency Services when called upon.

Councils are actively managing the risk of sea level rise and storm surge at St Kilda and the Globe Derby Park settlements. For the broader community, the impacts of sea level rise and storm surge is not well recognised, perhaps due to much of the zone being largely dedicated to salt production for more than half a century, and the nature of the mangrove, mudflat and samphire habitats which provide a natural barrier against storm surge events and coastal erosion. A lack of observation-based data in this environment also makes it difficult to identify trends in coastal changes so it is not possible to know when changes may exceed natural barriers. . This means that current warning systems and emergency response strategies may be inappropriate for extreme events along the coast. Furthermore, a lower community understanding and awareness of the potential risk from sea level rise and storm surges may lead to community opposition to adaptation changes such as development and recreational restrictions.

Access to good data and a narrative on how the frequency of fire ban days and the nature of heatwave events particularly during years in a strong El Nino cycle, creates a barrier to current and medium term planning and preparedness.

In addition, although the community is aware of, and have experienced, bushfire and extreme heat impacts, there is a lack of understanding regarding year-to-year variability, which may lead to “relaxed” attitudes. Such attitudes contribute to ongoing lifestyle preferences for “bush living”, which although aesthetically desirable, can place people in high risk areas or lead to increased dissonance if restrictions prevent development in such areas.

Key points

Facilitating adaptation to the increasing demand for emergency services will require the following adaptation options to be implemented now and over the next 5-10 years: early identification of areas at extreme risk; early warning systems for flood and fire; monitoring systems to inform decision making; and raising local community ownership and awareness of risks and impacts.

In addition, Council/regional emergency response plans should be tested and evaluated for continuous improvement and currency.

Planning should also start now to review the capacity and adequacy of volunteer services and where necessary, take step towards facilitating increased volunteerism and volunteer training.

Within 5 years the Playford Council Development Plan and Salisbury Council Development Plan should incorporate climate risk overlays for fire, flood and coastal inundation to guide development and Development Plan amendments which will assist in creating buildings and infrastructure resilient to extreme events.

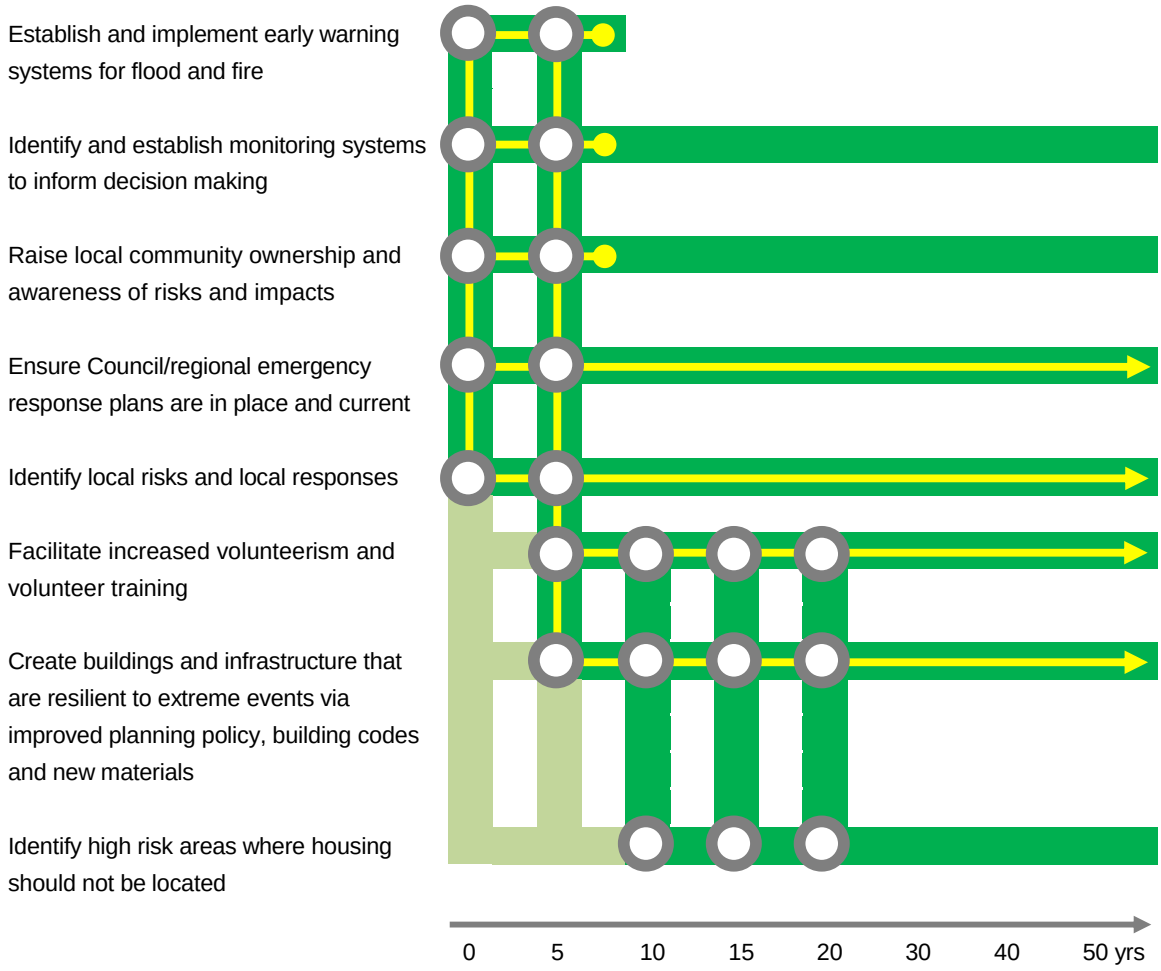

Figure 7. Adaptation pathway for extreme events and emergency management in Northern Adelaide.

5.5 Health and safety of vulnerable people

Key area of decision-making

How do we maintain and enhance the health, safety and wellbeing of vulnerable members of the community as the risk of extreme events such as heat waves and fire risk increases?

Northern Adelaide has 13% of the State's population, with a younger demographic than the average for the State. The region is one of the fastest growing in South Australia, with an additional 169,000 people expected to live in the region (including in the City of Tea Tree Gully) within 30 years, a 75% increase from the current population (Adapting Northern Adelaide, 2015b).

The health and safety of vulnerable members of the community is highly valued, reflecting the focuses of the City of Salisbury and City of Playford on promoting liveable communities and active and healthy lifestyles. However, while some measures of individual and community vulnerability are on par with the rest of the State, such as personal mobility, others such as rates of volunteering, the average wage, the percentage of dwellings rented from the Government and children in low income, welfare-dependent families, are higher than the State average.

Climate change impacts

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), projected warming and drying climate, together with increased risk of extreme events (e.g. heat waves and bushfire) will be particularly significant for the health and safety of vulnerable people. Specific concern regarding climate change impacts was identified in relation to people: needing assistance with core activities; with physical disabilities; with mental health issues; aged over 75 years; and, with low personal mobility.

Priority adaptation options

An immediate priority (**Figure 8**) to improve the health and wellbeing of vulnerable members of the community as the climate changes is to **scope potential Government responses to the provision of heat refuges**. This will require consideration of the roles and responsibilities of local versus state government, and liability issues regarding whether to encourage people to come to heat refuges or stay in their own homes. Green infrastructure (GI, supported by WSUD, can include alternative water sources for irrigation) and would be an important strategy to improve outdoor human thermal comfort, increasing the ability of people to operate outdoors and reducing the risks to people obligated to be outdoors

Another immediate priority, but one which requires ongoing implementation, is implementing and, where possible, **enhancing heatwave response services**. These include services such as the Australian Red Cross' Telecross REDi service and council-operated but federally-funded home and community care. Both have been recognised as playing an important role in notifying at risk residents during periods of extreme heat in recent years. The role of Council owned public libraries is also important to support vulnerable communities in accessing library services such as computer services and assistance.

There is a risk of increased abundance of mosquitoes and vector borne diseases in a warmer climate particularly and near wetlands, coastal areas where there is very shallow and static surface water.

Adaptation in the short term must also focus on **installing and maintaining back-up power supplies to offset the impacts of strategic power outages in the electricity grid**. This will require investment from local or state government, depending on the ownership of the facilities. Given that this issue is of broader interest to councils, particularly where pumped stormwater and wastewater management systems are established, there is a role for the Local Government Association of SA to play in working with SA Power Networks and SA Water to develop appropriate solutions.

Within five years, implementation of adaptation options (**Figure 8**) should focus on three main strategies. First, **implementing mechanisms to reduce power costs for vulnerable people**, which are recognised as a major cost of living pressure. This could be achieved through subsidies or power provider regulation for low income families. Second, **insurance policies of Local Government should be reviewed** to determine whether a broader range of services can be provided that will benefit vulnerable members of the community. This will need to be done in a way that recognises existing changes in risk management practices of insurance companies as they prepare to respond to growing climate risk. Third, there is a need to **adopt more climate-sensitive building designs** they provide improved living conditions for people within their own homes. This option has strong links with the climate-ready buildings key area of decision making (Section 5.2) and will be of benefit to all members of the community. In order to implement this option, attention will need to focus on working with DPTI, the Local Government Association and development industry peak bodies to change building code and planning regulations.

While not a priority option at this stage, it is recognised that amending development plans policies to include an overlay for climate risks including fire, flood and coastal storm surge could inform future developments and development plan amendments to prevent construction of community facilities in high risk areas may need to occur in the coming decade.

Triggers

The most important trigger for implementing adaptation options for vulnerable members of the community will be policy changes in local and state government regarding risk management and insurance, which will determine the extent to which government provides services on extreme heat days for older people and people with disabilities.
Other triggers will include when more frequent periods of extreme heat with three or more days over 40°C start to occur, or when there are major changes in responsibility for health and wellbeing service provision between Federal, State and local government and non-profit organisations.

When extreme events occur they also expose weaknesses in services and community preparedness. It is particularly important to have robust review processes to ensure that learnings are translated into corrective and preventative actions, particularly where there is harm to human health or fatalities.

Enablers and barriers to adaptation

Many of the features of the region relating to adaptation of vulnerable members of the community to climate change impacts may be viewed as enablers and barriers – with the context of application and community will tending to make the difference. For example, technological advances may underpin advanced warning systems and information dissemination, yet vulnerable members of the community, particularly the elderly, who may not be tech-savvy would be unable to access such alerts. Similarly, adaptation may be facilitated by well-informed and close-knit communities and businesses who provide collaborative partnerships to facilitate adaptation, but if such knowledge or connections are not available or fails then adaptation will be impeded. Building and planning regulations may also facilitate adaptation, but only if appropriate for the extreme events likely to be experienced under climate change.

Key points

Maintaining and enhancing the health, safety and wellbeing of vulnerable members of the community will require Government responses to the provision of heat refuges to be scoped over the next 5 years. In addition, implementing and enhancing heatwave response services and installing and maintaining backup power supplies to offset the impacts of power outages on strategic infrastructure will be a priority action starting now and continuing into the foreseeable future.

In 5 years' time, the following additional ongoing adaptation options should be implemented, though planning for these needs to start now: implement mechanisms to reduce power costs for vulnerable people; review Local Government insurance policies; and, adopt more climate-sensitive building designs.

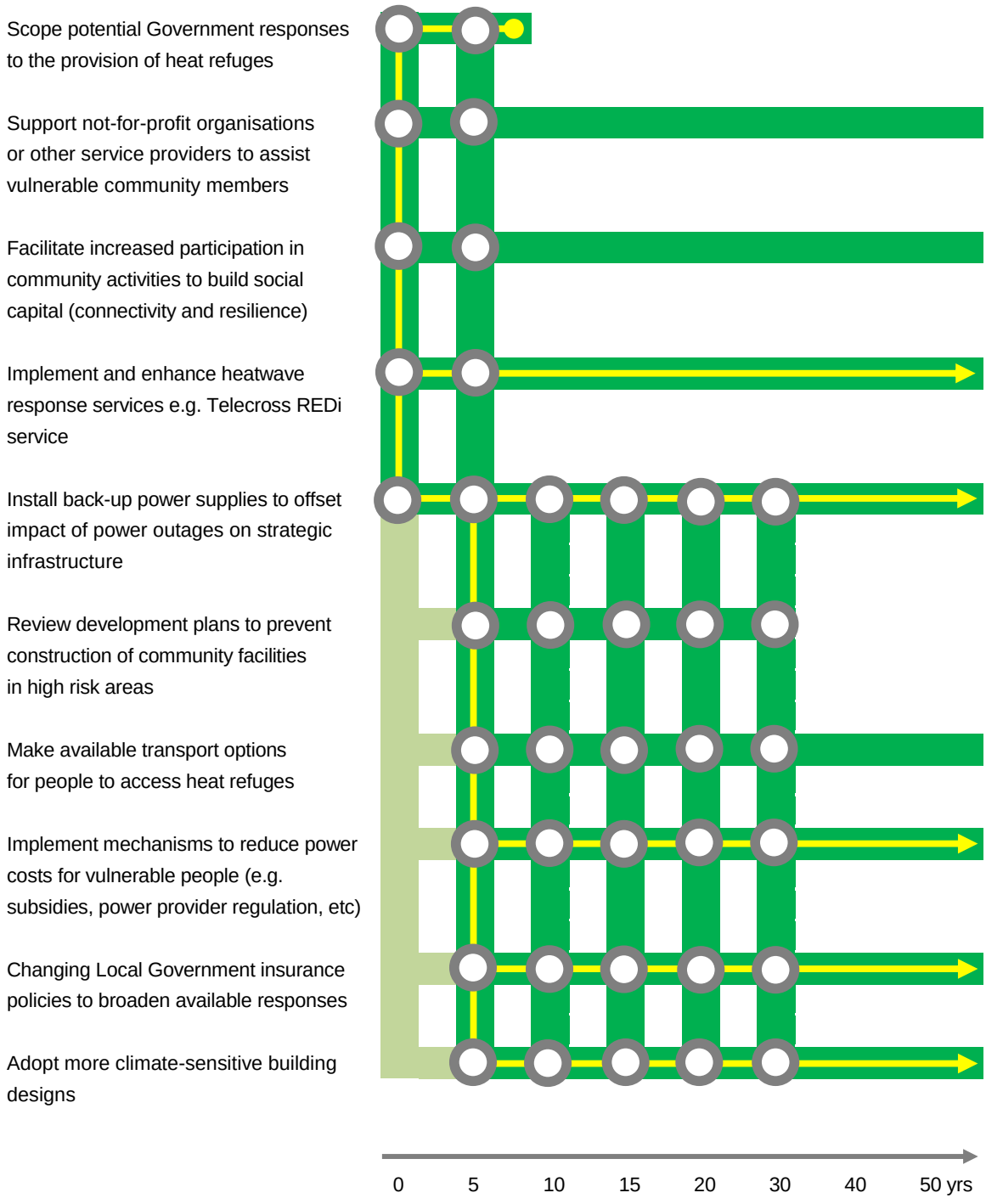

Figure 8. Adaptation pathway for health and safety of vulnerable people in Northern Adelaide.

5.6 Horticulture – Northern Adelaide Food Bowl

Key area of decision-making

How do we maintain the productivity of horticulture in the region as the climate becomes warmer and drier and the risk of extreme climatic events increases?

Horticulture in Northern Adelaide is highly valued for its contribution to the region's economy. The sector is worth an estimated $250M per annum with the main horticultural crops coming from protected cropping facilities like glasshouses, which produce tomatoes, capsicums and cucumbers, and broad acre horticulture, which produces crops such as potatoes, carrots, onions and brassicas. At over 500ha, the area of protected cropping is the largest in Australia. In addition, revenue also comes from perennial crops like almonds, olives and wine grapes.

The horticulture sector is a major employer in the region on- and off-farm. The region contributes strongly to the State's strategic priority of producing premium food and wine from our clean environment. Continued growth of horticulture in the region also aligns strongly with the Northern Economic Plan (Government of South Australia, 2016).

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), the productivity of horticulture will be influenced most by the projected warming and drying climate and the prospect of greater periods of extreme heat. Without adaptation, a warmer and drier climate will reduce the overall productivity of a variety of broad acre crops and influence factors such as the timing of flowering and length of growing season. Increasing periods of extreme heat could also result in periodic crop failure. Crops grown in protected cropping facilities like glasshouses have greater potential to be protected from adverse weather conditions (and hence have higher adaptive capacity), but like broad acre crops will require investment in adaptation options in order to maintain productivity.

More detailed information on the forecast impacts of climate change on horticulture in the region are also contained in Pitt et al. (2013).

Priority adaptation options

An immediate priority adaptation option for horticulture in Northern Adelaide is to **develop a land and water strategy** for crops, water supply infrastructure and soils (**Figure 9**). This strategy will outline how horticulture can continue to remain productive as the climate changes and expand in response to new water sources becoming available while addressing

risks that have arisen in the past in relation to land and water management (e.g. soil salinisation). This option can be progressed by preparing a business-case for presentation to PIRSA and Natural Resources Adelaide and Mount Lofty Ranges (AMLR NRM) Board). In developing the strategy, consideration also needs to be given to **developing better training programs and language communication support** given the large proportion of growers who are from non-English speaking backgrounds.

Given the reliance of horticulture in the region on irrigation and the importance that irrigation will play in maintaining productivity in a warmer and drier climate, another immediate adaptation priority is to **investigate improvements in rules for water allocation, harvesting and trading**. This will need to be progressed by the Department of Environment, Water and Natural Resources, with input from growers.

The final adaptation option that is considered to be an immediate priority (**Figure 9**) is **establishing and maintaining governance and coordinating arrangements** for the horticulture sector. This is considered a priority given the numerous industry groups and government agencies that have an interest in the region. While some governance structures do exist, these need to be reviewed to determine their suitability in building resilience in the region's horticulture sector in response to future climate change.

Within five years, the region will need to start implementing strategies for transitioning to hi-tech greenhouse clusters including identification of suitable locations (whilst supporting coexistence with in ground farmers). This has already commenced in some areas with recent work by PIRSA. Such hi-tech clusters are well suited to responding to future climate change because of their better use of water and energy efficiency. They will also help contribute to regional economic development.

There is a need for a collective approach to local drainage and disposal schemes for roof water, excess surface water and brine and groundwater pumped discharges in order to maintain productive capacity of soils.

A further adaptation priority to be implemented within five years is greater use of alternative water sources. This builds on the region's existing history using stormwater water and recycled water for industry and primary production. In the first instance this relates to greater recycled water being made available, which will occur following the pending upgrade of the Bolivar DAFF plant. However, consideration will also be required of how to increase desalination of drainage water or saline ground water. Implementing this option will require collaboration between the AMLR NRM Board, PIRSA, SA Water, industry groups and growers.

Triggers

A wide range of triggers exist that could lead to greater implementation of adaptation options for the horticulture sector. The most important trigger is considered to be summer water availability both in terms of quality (e.g. salinity) and quantity (pressure and flow).

Other triggers could include:

- extended heatwaves;
- spread of diseases (fungal and nematodes) leading to crop losses and price declines;
- soil salinities exceeding threshold levels for a range of crop types;
- continued urban growth impacting on land availability and price of farming land; and
- changes to prices and market access.

Enablers and barriers to adaptation

Taking actions to maintain the horticultural productivity in the region will be enabled by current best-practice knowledge and technologies which may be applied. However, there are perceived barriers to adaptation, primarily relating to:

- funding;
- appropriate infrastructure;
- coordination of growers and support for representative organisations to assist in communication and engagement;
- information dissemination to, and training for, growers; and
- political will and support to act across agencies.

Key points

Priority adaptation options for horticulture in the Northern Adelaide Food Bowl, which require implementation now and over the next 5-10 years, are: development of a land and water strategy for crops, water supply infrastructure and soils; develop better training programs and language communication support; and, investigate improvements in rules for water allocation, harvesting and trading.

Another priority option for implementation now and into the foreseeable future is to establish and maintain governance and coordinating arrangements. Planning for the following options will need to start now to enable implementation in 5years' time: enable strategies for transitioning to hi-tech greenhouse clusters and using alternative water sources.

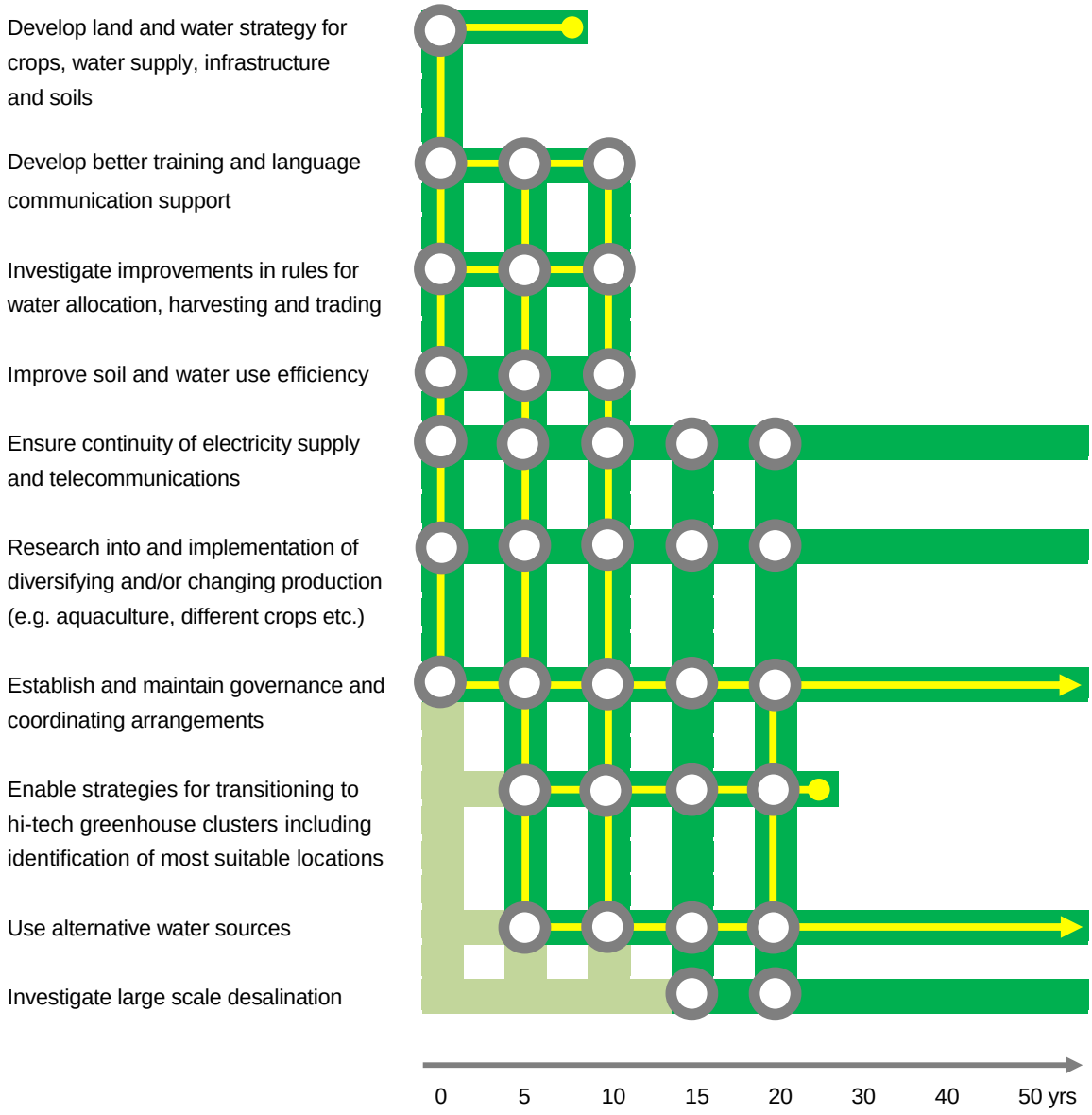

Figure 9. Adaptation pathway for horticulture – Northern Adelaide Food Bowl in Northern Adelaide.

5.7 Natural landscapes

Key area of decision-making

How do we maintain the condition and extent of natural landscapes across the region as the climate becomes warmer and drier and the risk of fire increases?

The Northern Adelaide region is comprised of highly valued and variable natural landscapes. While much of the land in the region is heavily urbanised there remains areas of important natural habitat. The predominant natural landscape types in the region (using the definition of West (2016) are the following areas:

- **Plains:** primarily located in the north and west of the region and typified by low elevation and topographic relief. In their natural state these landscapes are dominated by mallee and shrub ecosystems, although much of this land is now covered with houses or occupied by farming land in the Northern Adelaide Plains horticultural area;
- **Flanks (or hills-face):** form the transition zone between the plains and the upland (hills) landscapes and are typified by higher relief than the plains. Dominated by 'grassy' woodland and grassland ecosystems; and
- **Upland (or hills):** form the spine of the Mount Lofty Ranges and are typified by both high relief and elevation. Dominated by a diversity of both 'grassy' and 'shrubby' woodland ecosystems. In the Northern Adelaide region upland landscapes occur in the eastern part of the City of Playford (e.g. Para Wirra Conservation Park).

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), natural landscapes in the region will be influenced most by increasing fire risk, altered rainfall patterns (i.e. amount and timing), and increasing temperatures and heatwaves. Potential interactions between such climate change impacts and existing threatening processes (e.g. agriculture and urbanisation) will also be important to consider.

Plains landscapes tend to have low sensitivity to climate change and low adaptive capacity compared to flanks and upland landscapes. Comparatively, flanks landscapes have high sensitivity and low to moderate adaptive capacity; and upland landscapes have low to moderate sensitivity and moderate to high adaptive capacity. Exposure to climate change is higher on the plains due to higher climate velocity (i.e. the rate at which climate change affects the landscape; see Loarie 2009) and decreases towards the upland landscapes.

Priority adaptation options

The three natural landscape types in the region were assessed separately. However, there are some common adaptation options that will be required for all systems. In the coming five years, priority options will be (**Figure 10**):

- **strategic planning** across local and state government to support positive biodiversity outcomes and in particular, to connect open space for biodiversity corridors;
- **collaborating and managing across boundaries and agencies** to support migration and range shifts, as native flora and fauna respond to changing climatic conditions;
- **identifying and valuing ecosystem services**, including through the use of natural resource accounting. Research will also be required to explore the relationship between the condition of natural landscapes and human health;
- **minimising human-induced non-climatic stressors** to reduce threats; and
- **restoring, managing and monitoring ecosystem services and functions**.

There is a need to target adaptation strategies and actions according to the historic land use changes and modification that have occurred. In the least modified landscapes, efforts will need to focus on protecting and enhancing existing biodiversity values at landscape, ecosystem and species levels of organisation, which support ecological functions and associated ecosystem services. In the most modified landscapes, species-level conservation and habitat support is more appropriate, ensuring that the nature of landscape development does not compromise the provision of basic ecosystem functions (including those of biodiversity value in urban and peri-urban and farming landscapes).

Strategic planning to ensure positive biodiversity outcomes, cross-jurisdictional collaboration and management, and identification and valuation of ecosystem services should be a focus over the coming decade; whereas, reducing threats and restoring, managing and monitoring ecosystem services and functions will require long-term, ongoing investment.

Within five years the focus of adaptation in uncleared and least modified landscapes will need to broaden to include ecologically managing fire regimes at site and landscape scales.

In modified and cleared landscapes there will be a need to re-evaluate native species selections in planting activities to create more genetically resilient environments. Also required within 5 years is the regional planning to connect open spaces and enhance habitat poor segments of open space corridors in order for fauna and avifauna to be better able to re-assemble across different locations, and to access refuge, food and water.

The emphasis on these adaptation options differs between the three natural landscape types because of their respective exposure, sensitivity and adaptive capacity to climate change. For plains landscapes, being more heavily modified, the focus should be on increasing resilience by maintaining remnant habitat that provides ecosystem services (including

roadside vegetation, paddock trees and vegetation clumps) through the removal of threats and the repair of basic ecological functions. For urban biodiversity (acknowledging its limitation compared with natural landscapes) there will be a much greater opportunity to connect biodiversity initiatives with increasing investment in green infrastructure in urban and peri-urban areas.

For flanks landscapes, the focus should be on active adaptation through restoring, managing and monitoring ecosystem services and functions with an emphasis on protection of refugia and maintenance of natural features.

For upland landscapes, the focus should be on removing existing threats, repairing past impacts, and reinstating impaired ecological processes.

Triggers

A wide range of triggers exist that could lead to greater implementation of options to maintain the condition and extent of natural landscapes across the region. Triggers include:

- populations of species falling below viable levels, potentially including extinction of local populations;
- greater frequency of fire events, such as those that occurred on the plains at Pinery and in the hills-face and hills at Sampson Flat;
- restoration sites being found to not be successful at retaining existing habitat and biodiversity; and
- increased loss of biodiversity due to greater vegetation clearance for fire protection of private and public assets.

Enablers and barriers to adaptation

Maintaining the condition and extent of natural landscapes in the hills and Northern Adelaide Plains will be complex and require multi-sectoral involvement and a shift in community perceptions and attitudes towards natural environmental values. Minimising land-use intensification outside the existing footprint, and restoring habitat in landscapes are key steps towards maintaining landscape condition.

Extensive scientific knowledge regarding the multiple benefits of the natural environment to support human health and well-being, economic prosperity, and ecosystem functioning is starting to be more readily understood and adopted by the community and land managers and planners. For example, in the last 2-3 years, there has been a growing impetus (including at local, State and Federal government levels and in associated policies and strategies) to increase green infrastructure in urban areas as a means to ameliorate the combined negative impacts of urbanisation and climate change on humans and the environment (including water quality).

Key barriers to maintaining the condition and extent of natural landscapes includes a lack of:

- knowledge regarding ecosystem services and interactions between the environment and other land-practices (e.g. fire management);
- funding for research, implementation, management and monitoring;
- long-term monitoring and evaluation when options are implemented;
- legislative protection and appropriate council zoning and development restrictions which explicitly consider the protection of habitats, refugia and landscape linkages;
- land disposal decisions that may not incorporate biodiversity needs; and
- inappropriate land use change and development.

Key points

Maintaining the condition and extent of natural landscapes will require strategic planning to ensure positive biodiversity outcomes; collaboration across boundaries and agencies for migration and range shifts; identifying and valuing ecosystem services; connecting open space for biodiversity corridors and restoring, managing and monitoring ecosystem services and functions.

In 5 years' time, the focus of implementation will broaden to include ecologically managing fire regimes and re-evaluating native species used in plantings to create more genetically resilient environments; implementing these on time will require planning to commence now.

These options will need to be delivered in different ways across the region, with a focus on options that increase resilience in the plains and hills while supporting active adaptation in the hillsface.

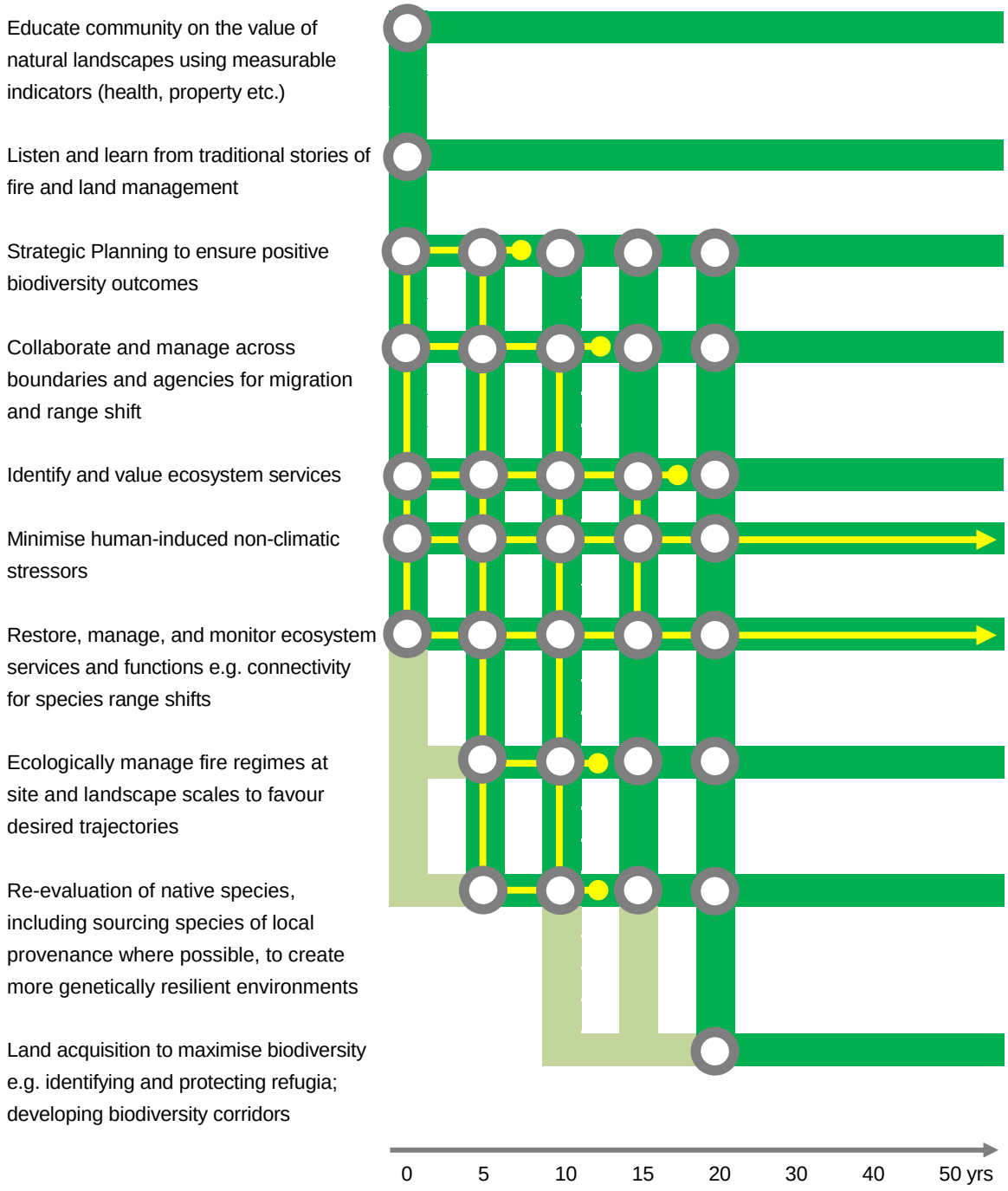

Figure 10. Adaptation pathway for maintaining the condition and extent of natural landscapes in Northern Adelaide.

5.8 Public open space and recreation

Key area of decision-making

How do we maintain and enhance the condition of open space and public realm as conditions become warmer and drier and the risk of climatic extreme increases?

Recreation opportunities in the region are provided by a range of outdoor facilities including open and green space, playgrounds, and walking and bike paths. These are highly valued by the community for their role in supporting community health, wellbeing and connectedness by providing opportunities for formal and informal recreation, health and fitness, social interaction, relaxation, and children's play and development.

There is nearly 50km^2 of local government open space in the region (9.4% of the total area). Reserves comprise the highest amount of open space (15.4km^2), followed by recreation (12.6km^2), and vacant land (12.3km^2) (Adapting Northern Adelaide, 2015b). A significant characteristic of most open space areas is green infrastructure, of which trees are the most commonly identified and readily measured element. Trees play an important role in overall functioning and wellbeing of the region, having benefit values not only for biodiversity in the region, but also on the health and wellbeing of people living and working in the region, the region's economic prosperity, and the resilience of the region to climate change (particularly increasing temperatures).

Based on an analysis of green infrastructure undertaken as part of the Adapting Northern Adelaide project, the region was found to have 12.61% canopy cover, with the City of Playford having slightly higher canopy cover than the City of Salisbury (14.2% and 11.01%, respectively). This assessment estimated that the tree cover in the region in 2010 provided over $3M worth of carbon dioxide sequestration services. (Adapting Northern Adelaide, 2015b).

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), the projected warming and drying climate, together with increasing sea level, bushfire risks and extreme heat days will have significant impacts on the condition of open space and public realm.

Priority adaptation options

Immediate priorities for adaptation (**Figure 11**) to maintain and enhance the condition of open space and public realm are to conduct further **research into the costs and benefits of WSUD** in Northern Adelaide. This needs to occur in parallel with continued efforts to

implement WSUD to maximise amenity and potential for water reuse (particularly in growth areas). The region is well positioned to do this given its history of stormwater management through constructed wetlands, which already provides irrigation water for parks and gardens. A significant focus of the research component of this work will need to be on determining the cost of supplying water to irrigate open space compared with the benefits gain through reduced urban heat island impacts during summer months.

Another option identified as an immediate priority is to **increase tree planting rates in urban areas** to increase shade, with a focus on vulnerable community hotspots. While the more significant impacts of extreme heat and the UHI effects may not be experienced for some decades yet, tree planting needs to commence now to ensure that a mature canopy develops within sufficient timeframes. Increasing the canopy cover in Northern Adelaide is likely to align with the objectives of the State Government's *30 Year Plan for Greater Adelaide*, as well as federal government urban canopy targets.

Increased investment in tree planting projects and revegetation will also present opportunities to **develop connected green spaces and corridors**, including wetlands, streetscapes, reserves. Not only will this help maintain and enhance the condition of open space and help species move and re-assemble across the region. it will also contribute to meeting objectives for natural landscapes and water dependent ecosystems.

While not proposed as immediate adaption priorities, there were a number of responses identified during the development of this Plan that will need to be considered for implementation in the future. These options include rationalising irrigated open space, increasing the number of indoor recreation facilities, and investigating innovative techniques for cooling the public realm (e.g. solar fans, cooled bus stops, shading techniques and wall gardens). Rationalising irrigated open space needs to be considered at the same time as investigations occur into the cost benefit of WSUD and as alternative water sources are developed (e.g. recycled water from future Bolivar DAFF plant upgrades) given that rationalising may not be required (or appropriate) if suitable water sources can be secured.

Triggers

The primary trigger that will influence the implementation of options to maintain and enhance the condition of open space and public realm is water price. In the Northern Adelaide region there are multiple water sources, and hence the price can vary significantly, with recycled and treated stormwater much cheaper than potable water supplies. Other triggers could include:

- availability of water from alternative sources such as aquifer storage and recovery;
- legislative change;
- community demand and expectations;
- more regular periods of drought conditions; and
- health impacts because of reduced liveability in the region because of UHI impacts.

Enablers and barriers to adaptation

Taking actions to maintain and enhance the condition of open space and public realm will be enabled by community aspirations and the recognised importance of open spaces for providing desirable lifestyle attributes, particularly for young and active people. This means that a high social value is often placed on such spaces, which will greatly facilitate a proactive approach to implementation of adaptation options. Demonstrated examples of the benefits of implementing similar adaptation options outside the region will also facilitate uptake within the region.

Despite this, it is anticipated that community engagement around adaptation options will still be important, especially around areas and impacts that are less well utilised and known. Competing priorities for land space and resources from opposing land uses, and political will and time frames will impact on implementation.

Reforms to address barriers to the implementation of WSUD should be promoted through Development Plans and the Building Code of Australia.

Key points

Priority adaptation options for maintaining and enhancing the condition of open space and public realm include researching the cost benefit of WSUD in Northern Adelaide; ongoing implementation of WSUD to maximise amenity and potential for water reuse; increasing tree planting rates in urban areas to increase shade; and, connecting green and blue spaces and corridors, including wetlands, streetscapes and reserves.

Reforms to address Barriers to the implementation of WSUD should be promoted through Development Plans and the Building Code of Australia.

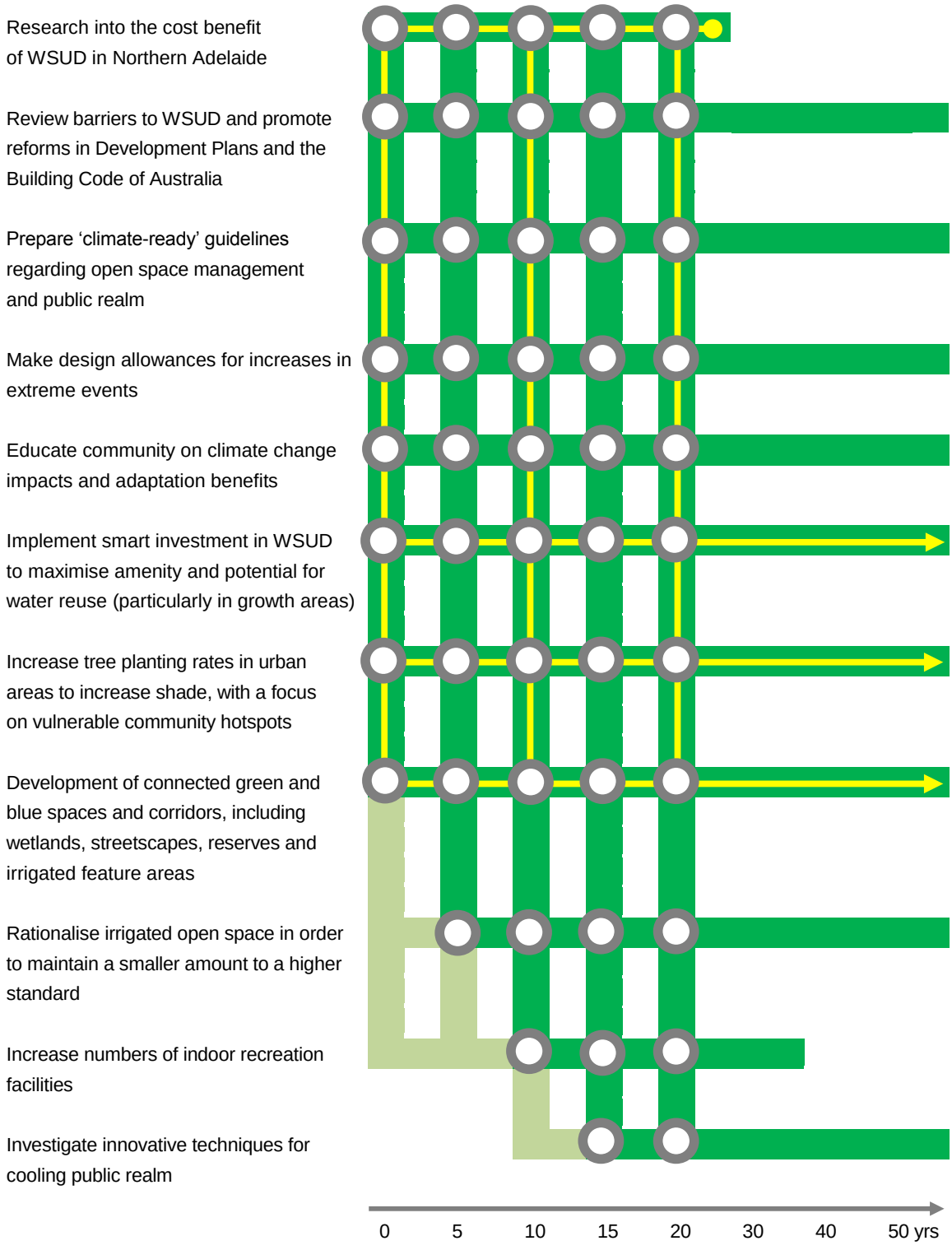

Figure 11. Adaptation pathway for maintaining and enhancing the condition of open space and public realm in Northern Adelaide.

5.9 Water dependent ecosystems

Key areas of decision-making

How do we maintain the condition and function of constructed wetlands dependent on surface water flows as rainfall quantity declines and intensity increases?

How do we maintain and build the resilience of natural wetlands and riparian zone communities along natural watercourses as the climate becomes warmer and drier?

Wetlands and riparian ecosystems are valued in the region for the multiple roles they play in supporting biodiversity, improving water quality, local cooling, providing water for industry and irrigation, and aesthetics. These also provide opportunities for linear trails and revegetation to create connected green open space.

Urbanised parts of the region have a well established reputation for innovative water management, especially the use of wetlands to harvest and re-use stormwater. Salisbury has more than 50 wetlands used as strategic catchment management tools, including the following sites[5]:

- Dry Creek Linear Park, Walkley Heights;
- Greenfields Wetland, Salisbury Highway;
- Kaurna Park, Waterloo Corner Road, Burton;
- Little Para River - Paralowie, Salisbury Downs, Salisbury and Salisbury Park; and
- The Paddocks, Para Hills.

Important stormwater management wetlands within the City of Playford include:

- Munno Para Wetland;
- Stebonheath Park Wetland; and
- Adams Creek wetland site.

In addition to constructed wetlands there are natural wetland systems that occur along the main watercourses in the region: Gawler River, North Para River and Little Para River. These natural wetland systems support a wide range of flora and fauna including numerous threatened species.

Potential impacts of climate change

Based on the Integrated Vulnerability Assessment conducted for the region (Adapting Northern Adelaide, 2015d), declining rainfall and the resulting altered flow and water regimes will have significant impacts on water-dependent ecosystems in the region. Increasing fire

[5] http://www.salisbury.sa.gov.au/Our_City/Environment/Water/Wetlands/Wetlands_Locations

risk, rainfall intensity, and average temperature will also play an important role in impacting on water quality and habitat availability.

Vulnerability of wetlands in natural catchments is particularly high because the adaptive capacity to declining rainfall is low. In contrast, constructed wetlands in urbanised catchments may be able to offset the impact of declining rainfall through increased run-off from expanding areas of hard (impermeable) surfaces in residential areas and projected increases in rainfall intensity, which will increase run-off. When integrated with water sensitive urban design, natural wetlands and urban water catchment provides multiple benefits to support the greening of communities, providing localised water sources improving water quality in runoff, and supporting urban biodiversity.

Priority adaptation options

Within the next decade the priority for adaptation for water dependent ecosystems will be to **identify thresholds for water quantity and quality in local catchments** and to **develop a regional stormwater management plan** across Council areas (City of Salisbury, City of Playford and City of Tea Tree Gully) (**Figure 12**).

The regional stormwater management plan will be developed in three steps: establish council-wide stormwater management plans; obtain State government ratification of the plan through the Stormwater Management Authority; and, establish a steering committee/regional board to develop a regional stormwater management plans based on the council-wide plans. Following completion of the regional stormwater management plan, **construction of stormwater infrastructure** that is integrated with Water Sensitive Urban Design, should occur across the region. It is anticipated that this will commence within five years (**Figure 12**).

A priority for implementation now, but that will require ongoing delivery in the decades ahead is to **improve sediment management during high/extreme events and during periods of upstream development**. This will reduce sedimentation in both constructed and natural wetlands.

The majority of priority adaptation options identified in this Plan for water-dependent ecosystems focus on constructed wetlands. Yet changing water regimes are likely to substantially alter the ecology of natural systems in the region. Reflecting this, West (2016) suggests that active adaptation to transformation may be required for water-dependent ecosystems such as pre-empting reassembly of these systems to maintain stability and ecological functions. This will require monitoring to determine when such a response should be implemented. Other adaptation options may include protecting base flows and identifying, protecting and developing corridors to enable species migration and re-assembly, potentially to wetlands in other parts of the Adelaide and Mount Lofty Ranges with more suitable water regimes.

Triggers

A wide range of triggers exist that could lead to greater implementation of options to maintain and build the resilience of water dependent ecosystems in the region. The most important triggers are considered to be:

- increasing numbers of pests within water bodies leading to health issues;
- oxygen depletion in the water column as a consequence of more algal blooms;
- increasing salt and turbidity levels;
- changes in rainfall intensity that reduce the harvestable volume of water;
- stormwater quality declines to the point that it is unusable;
- increasing periods between rainfall events resulting in decreased survival of aquatic species;
- greater environmental water needs resulting in larger releases from upstream water storages;
- higher evaporation levels resulting in more water being needed to maintain wetlands; and
- rising sea levels impacting on water harvesting and the presence of aquatic species in low elevation wetlands.

Enablers and barriers to adaptation

The demand for year-round water availability to support heavily irrigated areas and aesthetically valued waterbodies (e.g. ornamental lakes) will generate a need to ensure adequate quality water is available in the region, which will in turn benefit the condition, functioning and resilience of constructed wetlands as water storage features.

Although knowledge exists regarding stormwater modelling and how to retrofit infrastructure to help maintain wetlands and waterways, many solutions are often costly which may inhibit implementation. In addition, whilst development plans and government policies, such as the *30 Year Plan for Greater Adelaide*, may be able to facilitate adaptation through in-built environmental requirements and restrictions, such plans and policies currently lack adequate requirements to achieve protection of water-dependent ecosystems. The potential for flooding impacts from waterways and water bodies under extreme rainfall conditions may also prevent uptake of adaptation options, though with appropriate planning and infrastructure such flooding effects could be minimised.

Key points

Priority adaptation options for water-dependent ecosystems are to identify thresholds for water quantity and quality in local catchments, and to develop a regional stormwater management plan across Council areas. Improving sediment management during high/extreme events and during periods of upstream development will be an ongoing priority for implementation. In 5 years' time, building stormwater infrastructure that aligns with regional stormwater plans will become a high priority.

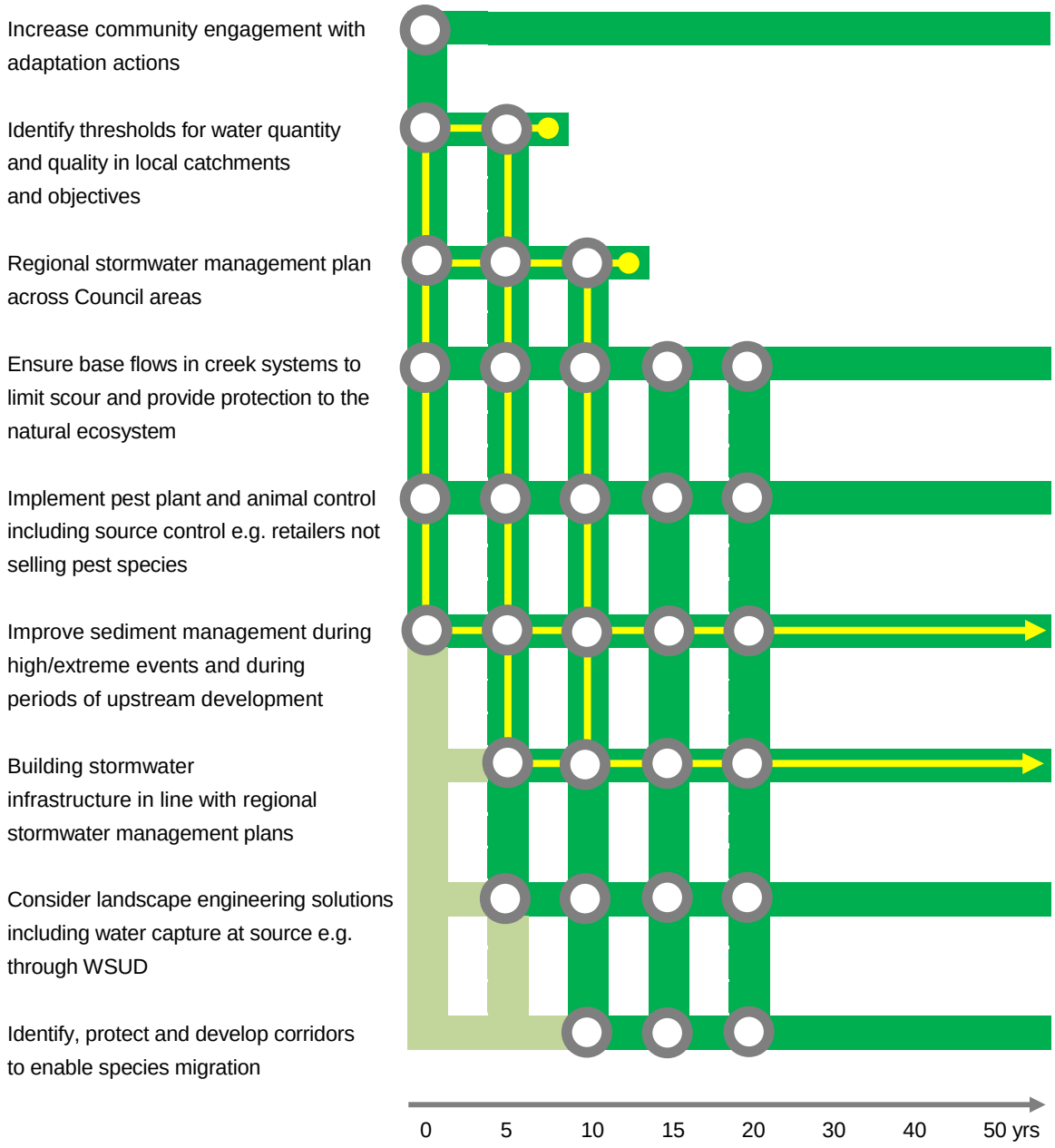

Figure 12. Adaptation pathway for maintaining and building the resilience of water dependent ecosystems in Northern Adelaide.

6 Implementing the plan

6.1 Our approach to taking action

Moving from the planning to implementation stage for Adapting Northern Adelaide will require a focus on:

- supporting options that look for opportunity as well as addressing risk;
- building the business case for action;
- working collaboratively across regional partner organisations; and
- raising awareness amongst the community of the impacts of climate change and how we can respond.

Balancing opportunity and risk

Adaptation in the region will seek to balance opportunity and risk. Many actions in this Plan will address climate risk and hence build resilience in the region's community, economy and environment; yet identifying opportunities is also a major feature. This will be achieved through options identified under the adaptive economy theme and through specific initiatives such as the Green Industries Program. The region is already on a footing to identify how local skills and experience in industries, such as manufacturing and food production and processing, research, development and innovation can address emerging climate related risks, and in turn how this aligns with emerging economic opportunities internationally.

The business case for action

The business case for action on climate change is becoming clear. By taking action now, we can reduce the impact and costs on the industry, community and governments (Federal, State and local) in the future. Within the region, Adapting Northern Adelaide partners will:

- identify opportunities within projects to build resilience to climate change. This recognises that the least-cost response to climate change is to consider future climate scenarios in projects that will already be undertaken; and
- Identify opportunities within services. For example, by integrating future climate into open space management activities, more suitable and efficient approaches to species selection and weed management by design can be fully realised.

New projects and programs will increasingly consider the use of economic analysis to identify the benefits of action now compared to later. An example of this type of analysis is presented in **Box 1**.

Collaboration

Many of the regional adaptation priorities identified for Northern Adelaide are based on existing approaches, strategies and technologies. However, delivering them in a way that

prepares the region for climate change will require regional-scale, cross-sectoral collaboration, including with industry and neighbouring councils and other regions (e.g. City of Tea Tree Gully, City of Port Adelaide-Enfield, District and Northern Corridor councils). Collaboration will be facilitated on a project-by-project basis by continuing to engage widely with the community and business sectors. At a project-scale, Adapting Northern Adelaide will continue to develop governance arrangements that involve key partners in the region.

Raising awareness and building community support

The major impacts of climate change will ultimately be on the community in the region. Continued engagement with the community is essential in order to ensure that the community: understands the impacts of climate change; knows how to respond; and, supports the work of Adapting Northern Adelaide partners in delivery of regional priority projects. This will occur on a project-by-project basis, as well as through communication and outreach initiatives. An example of a community engagement initiative used for Adapting Northern Adelaide was the *Adapt Your Patch* social media campaign (**Box 2**).

BOX 1

Economic Analysis Case Study

Heatwaves and Health Care Costs: Applying cost benefit analysis to climate change adaptation options with a focus on vulnerable community members

One of the potential outcomes of climate change is an increase in periods of extreme heat. These extreme heat waves pose a range of health risks to the community in general, but particularly to the most vulnerable members of the community particularly the old, the very young and the disabled.

To establish a methodology for helping to understand the cost of action (including no action) and the benefit of adaptation, a preliminary analysis was conducted using a Net Present Value framework. This focussed on estimating the increase in the cost of additional health care services associated with periods of extreme heat and also considered options for adapting to the health risks of vulnerable members of the community.

Cost information was based on Health SA studies into the historical relationship between heatwave and health care. Results from this work were combined with data on the costs of health care services (e.g. estimates of health service costs such as ambulance call outs, hospital admissions and emergency department presentation) and population projections .

Net present value calculations were developed for each of four scenarios:

- baseline (assumed no change in heatwave incidence from the 1995-2014 average)
- baseline plus demographic effects (no change in heatwave incidence but including the effects of an ageing population and associated slight increase in costs)
- baseline plus demographic effects and an increase in heatwave days based on an intermediate emissions scenario
- baseline plus demographic effects and an increase in the incidence of heatwave days based on a high emissions scenario.

BOX 1 contd.

The present value (cumulative for the period 2014-2050) of alternative cost scenarios is summarised as follows:

SCENARIO	Present value ($m)	Difference from baseline ($m)
Baseline costs	$1,322	
Baseline plus demographic effects	$1,333	$11
Baseline plus demographic effects plus intermediate emissions scenario (RPC4.5)	$1,518	$195
Baseline plus demographic effects plus intermediate emissions scenario (RPC8.5)	$1,642	$320

Because of the indicative nature of this analysis, the magnitude of these amounts is also indicative. The relative variations based on alternative scenarios indicate how these costs vary with alternative climate change scenarios.

An important result arising from this methodology is that it indicates the appropriate scale of adaptation options, in particular, the levels of adaptation costs that can be supported in order to achieve reductions in these heatwave related health care costs. For example, under an intermediate emission scenario (i.e. HWDs RCP4.5) an adaptation action that cost $100 million and resulted in a 50% reduction in these costs could be assessed as providing good value.

Adaptation options for addressing heat wave impacts would have different time profiles of expenditure. For example, the development of green infrastructure has long lead times and the costs in each period could be estimated and a present value calculation developed that could then be compared with the potential cost saving in reduced health service expenditure.

BOX 2

"Adapt Your Patch!" Community Engagement Campaign

As a way to start engaging the community and encouraging a culture of local-level adaptation, the ANA project ran a five week online campaign called "Adapt Your Patch!". The objective of this campaign was to inform the community about key adaptation challenges for the region and ways that we can all respond in our everyday lives. The Facebook social media platform was used as the basis for this campaign, together with the Adapting Northern Adelaide website (http://www.playford.sa.gov.au/adaptingnorthernadelaide). Each week of the campaign focusses on a new adaptation issue:

1. How do you avoid the heat at home?
2. How do you prepare for emergencies?
3. How can we cool our suburbs?
4. How can we build houses better adapted to Adelaide's increasingly hot weather? And
5. What new economic opportunities do you think will emerge as the climate changes?

Facebook users were invited to share, on the dedicated *Adapt your Patch!* Facebook page, written and photographic examples of adaptive actions applied in their own lives that address the six key issues.

The campaign generated a range of practical ideas on how people can, and do currently, respond to climate change in their own lives, such as:

- making cold and frozen drinks on hot days;
- closing all blinds, windows and doors for efficient electricity;
- sleeping with a wet a towel on your body;
- doing housework in the late evening when temperatures drop;
- filling the bath for the kids to use as an "indoor pool";
- using portable cookers to cook in the cooler and less used rooms, such as the laundry, bathroom or garage so that the heat is not in living areas; and,
- using alternative building materials and designs to create more resilient houses.

6.2 Regional priority adaptation options

Drawing on input from subject matter experts, key stakeholders with local knowledge and informed by leading practice from other regions, this Plan identified a broad range of adaptation options (**Attachment D**). Using an optimisation prioritisation framework that considered cost-benefit, regional relevance and practicality of delivery, a subset of these options were identified as regional priorities.

A summary of the regional priorities for Northern Adelaide are provided below. These provide the focal point for regional-scale, cross-sectoral collaboration for adaptation in the region. They aim to achieve a balance between addressing the risks of climate change while also capitalising on the opportunities. A summary of the alignment between these regional priorities and the strategic priorities for the City of Salisbury and City of Playford are provided in **Table 4**.

6.2.1 Building natural buffers to sea level rise

Unlike other major metropolitan areas along the coast in Australia, Northern Adelaide has a natural buffer to sea level rise provided by its coastal wetlands to the west of Port Wakefield Road. These need to be protected and enhanced through the following actions:

Continue and maintain modelling and mapping to assist with risk management: New stormwater and storm surge plans need to incorporate sea level rise spill and flood maps and revised rainfall and runoff modelling outputs. Such modelling should also consider the location of key infrastructure and future urban densification and development. Effective verification mechanisms should be in place to assure that development projects provide integrated climate resilience.

- Responsibility: City of Salisbury and City of Playford

Restore coastal and marine habitats: Councils can support DEWNR and AMLR NRM to investigate the preparation of a Coastal Retreat Plan with a focus on samphire and mangroves. Councils can assist by spatially identifying the potential areas for restoration.

- Responsibility: DEWNR, AMLR NRM

6.2.2 Creating liveable communities through climate ready developments

Climate-ready developments will support liveable communities by improving living conditions, which is especially important for vulnerable members of the community. This will also present an economic opportunity for local industry, with this becoming a major focus for adaptation in regions elsewhere in Australia.

Prepare guidelines for developers and builders to encourage greater use of climate-ready building techniques and site development: Develop guidelines that contain

principles and targeted outcomes that will encourage and guide developers on how to contribute to climate-ready, efficient and sustainable buildings and development.

- Responsibility: City of Salisbury and City of Playford

Identify barriers to implementing suitable climate-ready housing under the existing provisions of the Building Code of Australia: Councils will support DPTI to take a lead role in identifying and addressing barriers that are delaying the progress of improved building performance requirements under the Building Code of Australia.

- Responsibility: Department of Planning, Transport and Infrastructure, City of Salisbury and City of Playford

Raise community and industry awareness about the benefits of climate-resilient buildings, developments and urban environments: Develop key messaging and advice for the community about the benefits of climate resilient buildings. In key development projects where feasible, Councils will describe and promote outcomes sought for smart, green and liveable places that address current and emerging climate impacts, including for residential, sports, commercial and industrial precinct developments.

- Responsibility: City of Salisbury and City of Playford, businesses, Department of Planning, Transport and Infrastructure.

Propose amendments to the Building Code of Australia and council development plans: Councils will explore potential amendments to the Building Code of Australia and council development plans, aiming to increase the number of climate -ready homes and developments constructed. Councils will lead by defining aspirational outcomes sought for development on council-owned land. Responsibility: City of Salisbury and City of Playford and the Local Government Association.

6.2.3 Reducing the risk of climate hazards to community health and well being

An increase in the frequency and intensity of climate related hazards such as extreme heat, fire and flooding will impact the liveability of the community, especially for vulnerable people. Addressing these risks now increase community resilience and reduce the cost of responding to climate hazard related impacts in the future.

Identify areas where 'at risk development' should not be located and ensure Development Plan amendments guide development that is resilient to climate impacts: Using spatial analysis techniques, locations will be identified where there is a high risk of the impacts of climate hazards to current and proposed developments. This analysis will consider extreme heat, bushfire and storms/flooding to guide appropriate zoning.

- Responsibility: City of Salisbury and City of Playford

Review local risks and responses to climate event hazards: Conduct emergency preparedness reviews to stress test responses to current plausible worst-case conditions and identify potential gaps in community support, health and emergency services.

- Responsibility: City of Salisbury and City of Playford, SAFECOM and Health SA

6.2.4 Adapting the economy through investment in horticulture

Responding to climate change will present economic opportunities where there is alignment between local industry skills and capabilities and emerging international markets for climate-ready goods and services. Building an adaptive economy will create jobs for an educated and skilled workforce.

Develop better training and language communication support in areas such as soil and salinity management: Councils, with the support of Natural Resources Adelaide and Mounty Lofty Ranges (AMLR NRM), will continue with the engagement of growers in preparing soil and salinity management plans for the Northern Adelaide horticultural area. This may include an approach to support land use and irrigation that is best suited to local geology, aquifer resilience and soil constraints.

- Responsibility: AMLR NRM, supported by the City of Salisbury and City of Playford

Improve land and water management practices: Investigations will occur to improve rules for water allocation, harvesting, trading and brine disposal. This is especially relevant to water management strategies related to adapting to warmer and drier conditions. Councils will support the existing work of AMLR NRM and the EPA to address reforms required and development of runoff and brine disposal strategies.

- Responsibility: AMLR NRM, EPA, City of Salisbury and City of Playford

Use alternative water sources: Continue to increase the use of water from alternative sources such as roof runoff, aquifer storage and recovery schemes, recycled wastewater or desalination of saline ground water. This will delivered by continued engagement with SA Water and horticulturalists.

- Responsibility: SA Water, horticulturalists, City of Salisbury and City of Playford

6.2.5 Smart investment in urban green space and natural environments that underpin community and economic prosperity

Investment in green infrastructure, green open space and natural environments will deliver multiple benefits to the community and business sectors. One of the major benefits will be to address the urban heat island effect, which will be exacerbated as a consequence of climate change drive increases in extreme heat in the future.

Develop connected green and blue spaces and corridors: Review council owned land parcels to identify those with the potential to create or maintain connected green spaces and

corridors, particularly along major roads, rivers, creeks and coastal areas. This will assist to retain land parcels that can support green open space and connectivity.

- Responsibility: City of Salisbury and City of Playford

Increase appropriate tree planting rates in urban areas: Map and plan an urban heat island reduction program for the hottest urban areas as part of amenity improvement works, linked to strategic asset management plans. Increasing appropriate tree-planting rates in urban areas will provide shade to cool streets and buildings, with a focus on vulnerable community hotspots.

- Responsibility: City of Salisbury and City of Playford

Make design allowances for increases in extreme events: Working with Council engineers and planners, ensure that where structures are built in high risk zones they are designed to cope with increasing risks from climate hazards such as flooding, storm surge, heatwaves and bushfire. This action will investigate risks in planning zones and assess risk liability where exposure to extreme events remains a concern.

- Responsibility: City of Salisbury and City of Playford

Prepare 'climate-ready' guidelines regarding open space management and landscaping: Consolidate the corporate knowledge of open space staff in a set of guidelines that improve open space outcomes. The guidelines will address irrigation, drainage, shade provision, and the selection of tree species that are low maintenance, climate resilient, and provide benefit to people and biodiversity.

- Responsibility: City of Salisbury and City of Playford

6.2.6 Supporting resilient natural landscapes

The Northern Adelaide region has significant natural areas of high biodiversity value such as coastal and freshwater wetlands, as well as plains, hills-face and hills landscapes. These areas are important from a conservation perspective as well as underpinning many community and economic values in the region.

Better managing threats such as pests and diseases: Monitor pest and disease extent and outbreaks that impact communities, farming and biodiversity. Strategies should be effective in coping with new and changing risks from climate change, including mosquito abundance (and related diseases), fruit fly, caltrop, buffel grass, and silverleaf nightshade.

- Responsibility: City of Salisbury, City of Playford, Natural Resources AMLR and PIRSA

Encouraging land-use changes with positive biodiversity outcomes: Working with DEWNR, AMLR NRM and DPTI, renewed efforts will be required to promote the principles and outcomes sought for positive biodiversity outcomes when land use is changed (Examples include the salt fields and crystallisation ponds and in new precinct developments).

- Responsibility: DEWNRAMLR NRM, DPTI, City of Salisbury, City of Playford

Protect existing natural features: Identify key natural assets and areas that require additional monitoring and protection (e.g. significant trees, remnant native vegetation, and refugia) including through the utilisation of existing information such as the Mount Lofty Ranges Bushfire Asset Register.

- Responsibility: DEWNR, AMLR NRM, City of Salisbury and City of Playford

Restore natural landscapes: The focus of restoration needs to be on reinstating impaired ecological functions, and addressing grazing and fire disturbance dynamics. Councils can contribute to this by using land management and environment teams to continue engagement with landholders to support broader landscape-scale adaptation strategies.

- Responsibility: DEWNR, AMLR NRM, City of Salisbury and City of Playford

Strategic Planning to ensure positive biodiversity outcomes: Councils will continue to work with DEWNR and AMLR NRM to develop strategies that result in positive biodiversity outcomes. These need to support actions that increase resilience in plains and hills landscapes and promote active adaptation for hills-face landscapes.

- Responsibility: DEWNR, AMLR NRM, City of Salisbury and City of Playford

6.2.7 Green industries for a prosperous and vibrant local economy

As part of developing an adaptive economy and recognising emerging opportunities, the region will develop a Northern Adelaide Green Industries program. This will support the deployment of Northern Adelaide's educated and skilled workforce and a prosperous and vibrant local economy.

Northern Adelaide Green Industries Program: The vision for the Northern Adelaide Green Industries Program is to establish Northern Adelaide as a nationally and globally recognised green industries region. The Program would support a Green Industries Cluster to strengthen networks and improve green and low carbon growth opportunities.

The types of business activities that will contribute to green industries include: horticulture, food processing and value adding, water management, use of recycled water, renewable energy systems and components manufacturing, environmental restoration on land and coastal regions, carbon offset creation, tourism (associated with the Adelaide International Bird Sanctuary and tourism of green industries), green industry services, and any activities that assist business to become greener and resource efficient.

In the immediate short term (12-18 months), a brand and promotional framework would be developed for participating businesses and a Green Industries Roadmap would be prepared. The cluster would support a regional approach to tackle opportunities, barriers and reforms.

- Responsibility: Department of State Development, local business and industry, City of Salisbury and City of Playford

Table 4. Alignment of regional priority options with the City of Salisbury's and City of Playford's strategic plans.

PRIORITY OPTION	PLAYFORD STRATEGIC PRIORITY	SALISBURY STRATEGIC PRIORITY
Building natural buffers to sea level rise		
Continue and maintain modelling and mapping to assist with risk management	Strategy 1 Our foundations Smart service delivery Smart living	Sustainable City Proactively manage stormwater to reduce its impact on communities and the natural environment.
Restore/maintain coastal and marine habitats (e.g. sea grass beds, samphire)	Strategy 2 Securing Playford's Future and Building Value Smart service delivery Smart living	Sustainable City Manage coastal environments to ensure their future natural, economic and recreational value.
Creating liveable communities through climate ready developments		
Prepare guidelines on how to encourage greater use of climate ready building techniques and site development	Strategy 2 Securing Playford's Future and Building Value Smart CBD Smart living	Liveable City Provide for a range of housing options appropriate for our diverse community
Identify barriers to implementing suitable climate-ready housing under the existing provisions of the building code	Strategy 2 Securing Playford's Future and Building Value Smart living	Liveable City Assist the community to reduce cost of living pressures through the adoption of energy efficient technologies
Raise awareness about the benefits of climate-resilient buildings/ developments and urban environments	Strategy 2 Securing Playford's Future and Building Value	Liveable City Innovative environmental management in water, energy, waste and biodiversity • Salisbury City Centre • Adelaide Airport Food Processing Hub • Precincts

PRIORITY OPTION	PLAYFORD STRATEGIC PRIORITY	SALISBURY STRATEGIC PRIORITY
Propose amendments to the development plan where relevant	Building our Capabilities Smart service delivery Smart living	Enabling Excellence Work with State and Federal Governments to influence policy and investment decisions
Reducing the risk of climate hazards to community health and well being		
Identify areas where housing should not be located (e.g., for heat waves, flood/storm surge and bushfire)	Strategy 1 Our foundations Smart living Smart service delivery	Sustainable City Have urban and natural spaces that are adaptive to future changes in climate
Review local risks and responses to climate event hazards (e.g. heat waves, heat islands, bushfire, flood & storm surge risks)	Strategy 1 Our foundations Smart living Smart service delivery	Sustainable City Have urban and natural spaces that are adaptive to future changes in climate
Adapting the economy through investment in horticulture and green industries		
Develop better training and language communication support in areas such as soil and salinity management	Strategy 4 Securing Playford's position in the global economy Smart jobs and education	Prosperous City • Be the place of choice for businesses to invest and grow in South Australia, nationally and internationally • Further develop Salisbury Water through research and development to provide a competitive edge for firms located in the region
Investigate improvements in rules for water allocation, harvesting, trading and brine disposal particularly relating to drought and heatwave adaptation	Strategy 4 Securing Playford's position in the global economy Smart jobs and education	Prosperous City Have a thriving business sector that supports community wellbeing, is globally oriented and creates job opportunities

PRIORITY OPTION	PLAYFORD STRATEGIC PRIORITY	SALISBURY STRATEGIC PRIORITY
Use alternative water sources (e.g. roof runoff, surface water, ASR schemes recycled wastewater or desalination of saline ground water)	Strategy 4 Securing Playford's position in the global economy Smart jobs and education Smart living	Prosperous City Further develop Salisbury Water through research and development to provide a competitive edge for firms located in the region
Investing in urban green space and natural environments that underpin community and economic prosperity		
Development of connected green and blue spaces and corridors for multiple benefits, including wetlands, streetscapes, reserves	Strategy 2 Securing Playford's Future and Building Value Smart Living Smart jobs and education Smart Health	Sustainable City Improve our attractiveness as a visitor destination and a place to live through the management of our trees, parks and wetlands
Increase appropriate tree planting rates in urban areas to increase shade and cool streets with a focus on vulnerable community hotspots	Strategy 2 Securing Playford's Future and Building Value Smart Living Smart jobs and education Smart Health	Sustainable City Moderate the impact of extreme heat events through Council's approach to street tree planting and management.
Make design allowances for increases in extreme events such as flooding, storm surge heatwaves and bushfire	Strategy 1 Our foundations Smart Service Delivery Smart living	Sustainable City Proactively manage stormwater to reduce its impact on communities and the natural environment.
Prepare 'climate-ready' guidelines regarding open space management and landscaping including appropriate species selection	Strategy 1 Our foundations Smart Living Smart Service Delivery	Sustainable City Moderate the impact of extreme heat events through Council's approach to street tree planting and management.

PRIORITY OPTION	PLAYFORD STRATEGIC PRIORITY	SALISBURY STRATEGIC PRIORITY
Supporting resilient natural landscapes		
Better managing threats such as pests and diseases that impact communities, farming and biodiversity	Strategy 2 Securing Playford's Future and Building Value Smart Living Smart jobs and education	Sustainable City Capture economic opportunities arising from sustainable management of natural environmental resources, changing climate, emerging policy direction and consumer demands
Encouraging land use changes with positive rather than negative biodiversity outcomes where possible	Strategy 2 Securing Playford's Future and Building Value Smart living	Sustainable City Have natural resources and landscapes that support biodiversity and community wellbeing
Protect existing natural features eg significant trees and remnant native vegetation	Strategy 2 Securing Playford's Future and Building Value Smart living	Sustainable City Have a community that is knowledgeable about our natural environment and embraces a sustainable lifestyle
Restore natural landscapes by reinstating impaired ecological functions and processes such as grazing and fire disturbance dynamics	Strategy 2 Securing Playford's Future and Building Value Smart living	Sustainable City Manage our natural spaces and landscapes to support the health of local habitats.
Strategic Planning to ensure positive biodiversity outcomes (state and council level)	Strategy 2 Securing Playford's Future and Building Value Smart living	Enabling Excellence Strengthen partnerships that enable us to better address our community's priorities
Proposal: – Northern Adelaide Green Industries Region		
Vision Northern Adelaide - A nationally and globally recognised Green Industries Region	Strategy 4 Securing Playford's Position in the global economy Smart Jobs and education	Prosperous City Be the place of choice for businesses to invest and grow in South Australia, nationally and internationally

6.3 Periodic review

As the climate changes and information and modelling is refined, we will gain a greater understanding of the impacts on key sectors in the region and possible opportunities. This will mean that adaptation options will also require periodic review to reflect best scientific knowledge as it becomes available. Such reviews may result in the need for a change in which adaptation options are implemented (i.e. some will commence whilst others may cease). Entirely new options will also emerge.

Reviews can be designed to coincide with regional partner planning review timeframes, the emergence of significant new understanding or innovation, or the availability of new climate projection data from the IPCC, which occurs about every five to six years.

Identifying indicators which enable the success of priority adaptation options to be monitored and evaluated will facilitate periodic review and an understanding of whether triggers for decision-making are being met. Developing such indicators can build on the triggers identified for each of the individual key areas of decision making themes outlined in this Plan. This will likely involve a combination of climate and system related indicators.

Future reviews should also consider when adaptation may need to move beyond continuing with existing best practice towards greater transformational responses, such as may be the case where people or infrastructure may need to be relocated away from high risk areas.

Given that both information and impacts will change, it should be acknowledged that the responses to the changing climate will also need to be adaptive. It is recommended that climate change indicators, impacts and progress toward implementation of actions be reviewed at least every two years.

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8 Glossary

Unless stated otherwise, all definitions are from IPCC (2013a; 2014)*.*

Adaptation - The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

> ***Incremental adaptation*** Adaptation actions where the central aim is to maintain the essence and integrity of a system or process at a given scale.
>
> ***Transformational adaptation*** Adaptation that changes the fundamental attributes of a system in response to climate and its effects.

Aerosol - A suspension of airborne solid or liquid particles, with a typical size between a few nanometres and 10μm that reside in the atmosphere for at least several hours. Aerosols may influence climate in several ways: directly through scattering and absorbing radiation and indirectly by acting as cloud condensation nuclei or ice nuclei, modifying the optical properties and lifetime of clouds.

Atmosphere - The gaseous envelope surrounding the Earth.

Baseline/reference - The baseline (or reference) is the state against which change is measured.

Climate - Usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years.

Climate change - Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

Climate change in Australia (CCIA) – a national-focused climate change project released in February 2015 and led by the CSIRO and Bureau of Meteorology (CSIRO and Bureau of Meteorology 2015).

Climate model (spectrum or hierarchy) - A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties.

Climate variability - Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events.

Emission scenario - A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g., greenhouse gases, aerosols) based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships.

Greenhouse gas - Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds.

Global climate model (GCM) – also called general circulation models are mathematical representations of the climate system which explicitly represent large-scale synoptic features of the atmosphere (CSIRO and Bureau of Meteorology, 2015).

Integrated vulnerability assessment (IVA) – a process used to assess the likelihood (or exposure) and consequence (or sensitivity) of climate change impacts on key issues, as well as assessing the adaptive capacity of issues in order to ensure a full understanding of vulnerabilities (Local Government Association of South Australia, 2012).

Key Area of Decision Making - An area of decision-making in an organisation, sector or region within which adaptation options may be needed to manage the impacts of climate change on an asset, value or service (Siebentritt & Stafford Smith, in review).

McArthur Forest Fire Danger Index (FFDI) - The McArthur Forest Fire Danger Index (FFDI) is widely used to forecast the influence of weather on fire behaviour. FFDI is based on the temperature (˚C), T, wind speed (km h-1), v, relative humidity (%), RH, and a component representing fuel availability called the Drought Factor (Dowdy, et al., 2009).

Mitigation - A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Projection - A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized.

Radiative forcing - Radiative forcing is the change in the net, downward minus upward, radiative flux (expressed in W m–2) at the tropopause or top of atmosphere due to a change in an external driver of climate change.

Regional climate model (RCM) - A climate model at higher resolution over a limited area. Such models are used in downscaling global climate results over specific regional domains.

Representative concentration pathways (RCP) - Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases and aerosols and chemically active gases, as well as land use/land cover.

South Australia Climate-ready (SACR) – A Goyder Institute research project to develop an agreed set of downscaled climate change projections for South Australia to support proactive responses to climate change in water resource planning and management at a State and regional scale (Goyder Institute for Water Research, 2015).

Trigger - When a monitored system driver (e.g. sea level rise or temperature rise) changes to a point where existing response options should be reviewed and new options implemented, i.e. a decision point is triggered. A trigger may occur without a threshold yet being reached (e.g. a degree of sea level rise not yet expressed in terms of a bad flood because a storm tide has not yet happened), but the conditions are set for a system threshold to be crossed before decision-makers can do anything about it. Note that a trigger should be easily monitored, for quick action.

Attachment A - Adaptation pathways analysis

Adaptation pathways provides a way of considering and visualising adaptation options. Rather than being limited to identifying the best single set of adaptation options for a limited set of climate change scenarios, it enables decision makers and communities to consider a range of possible actions, how they will be impacted by climate change through time, and whether any options have a 'use-by-date' (i.e. a point in time at which they are no longer viable or useful for addressing the impact being experienced).

Pathways maps enable the exploration of what combination of options are most suitable for adapting to future climate change and how these could be sequenced over time (i.e. what should be done now, versus what can be delayed). This type of analysis can break down the disempowering sense that 'everything' will be affected by climate change, or that everything needs to be done at once. (Siebentritt & Stafford-Smtih, In review)

The horizontal axis of the pathway shows both a timescale, and expected changes to the climate that are relevant to the key area of decision making. The range of adaptation options identified for the key area of decision making are listed on the vertical axis of the pathways map.

Figure A.1describes the symbology used on each pathways map. A vertical line through 'decision point' circles identifies a point in time at which a decision needs to be made between different options. The timing of the decision is indicative relative to the x-axis. This is based on the premise that as climate changes some options will become less suitable as adaptation measures and so new ones may be required. The length of the horizontal lines shows how long the option can be expected to effectively address the key area of decision making.

The preferred pathway (yellow line/s, see Figure A.1) identifies which options should be progressed now and into the future based on currently available information and preferences for implementation, including information provided by stakeholders at adaptation workshops. The preferred pathway does not preclude current actions that contribute to future adaptation from continuing but rather indicates actions over and above current practice that are required to enable adaptation to climate change impacts.

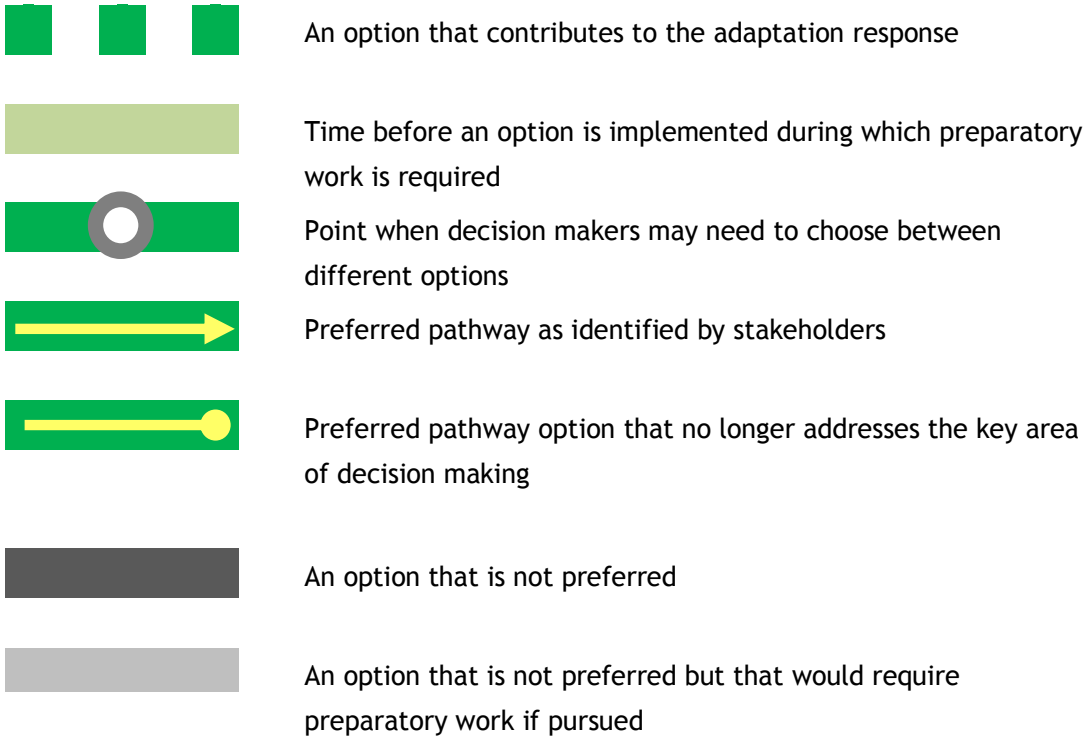

Figure A.1. Adaptation pathways map legend.

Attachment B - Workshop and focus group participants

Stakeholders (including steering committee members) involved in developing the Adapting Northern Adelaide Climate Change Adaptation Plan. Listed stakeholders attended either a project workshop or focus group. People shown in bold text are members of the project's steering committee.

NAME	ORGANISATION
Melissa Allery	City of Salisbury
Jenny Awbery	DEWNR
Zafi Bachar	NR AMLR
Warrick Barnes	DEWNR
Stephanie Bolt	Adelaide Airport Limited
Mellissa Bradley	Water Sensitive Urban Design
Victoria Brown	Local Government Association
David Bryant	City of Salisbury
Sian Campbell	City of Playford
Andy Chambers	Seed Consulting
Veronica Clayton	DEWNR
David Clayton	City of Salisbury
Liz Connell	SAFECOM
Tamika Cook	City of Salisbury
Robyn Cook	City of Salisbury
Ashley Curtis	City of Playford
Claude Dagescy	IXL Solar
Ken Daniel	City of Playford
John Darzanos	City of Salisbury
Richard Day	Department of State Development
Phil Donaldson	Sustain SA
Julie Douglas	City of Salisbury

Peter Doumouras	DEWNR
Michelle English	DEWNR
Shaun Fielding	City of Playford
Tony Flaherty	DEWNR
Karen Frear	City of Playford
Julie Fyfe	City of Salisbury
Joan Gibbs	University of South Australia
Hamish Gordon	PIRSA
Graham Green	DEWNR
Craig Heidenreich	Water Utilities
Mal Hemmerling	City of Playford
Jon Herd	City of Tea Tree Gully
Sara Hobbs	City of Playford
Megan Howard	City of Playford
Greg Ingleton	SA Water
Craig Johansen	City of Salisbury
Paul Johnson	City of Playford
Julie Kalms	City of Salisbury
Nicola Kapitza	City of Salisbury
Tim Kelly	**City of Salisbury**
Shaun Kennedy	City of Playford
Sam Kenny	City of Salisbury
Ben Kirchner	Polaris Business and Innovation Centre
Andrew Klos	DEWNR
Janine Kraehenbuehl	DEWNR
Aleisa Lamanna	DEWNR
Ly Luan Le	Vietnamese Farmers Association of SA
Andrew Legrand	City of Salisbury
Bianca Lewis	City of Salisbury
Sabina Lloyd	Uniting Communities
Mal Lowen	Department of State Development

Taryn Mangelsdorf	DEWNR
Chris Mcdermott	City of Salisbury
Lisa McDonald	University of South Australia
Joanne Menadue	City of Salisbury
Jeremy Miller	Sustainability House
Simon Molloy	SKC Consulting
Damien Moroney	NR AMLR
Carol Muzyk	City of Playford
Bruce Naumann	City of Salisbury
Andrew Nesbitt	City of Playford
Peter Newland	Newland Water
Monika Nitschke	Regional Adaptation Reference Group
Michael Oborn	City of Salisbury
Jo Park	City of Playford
Greg Pattinson	City of Playford
Mark Perrett	City of Playford
Pam Pindral	City of Salisbury
Sheryn Pitman	Botanic Gardens
Harry Pitrans	City of Salisbury
Ken Potter	City of Playford
Mark Purdie	City of Salisbury
Jason Quinn	DEWNR
Greg Ratsch	City of Salisbury
Mike Richards	City of Playford
Bryan Robertson	Hortex
Karen Rouse	SA Water
Dameon Roy	City of Salisbury
Wasim Saman	University of South Australia
Verity Sanders	City of Port Adelaide Enfield
John Spoehr	University of Adelaide
Phil Stump	Polaris Business and Innovation Centre

Terry Sutcliffe	City of Salisbury
Bronwyn Thomas-Cece	Uniting Communities
Murray Townsend	DEWNR
Pat Trimboli	City of Salisbury
Michelle Tucker	City of Salisbury
Parag Vishwasrao	City of Playford
Dale Welsh	City of Playford
Riccardo Zahra	City of Salisbury
Esteban Zepada	University of Adelaide – Student Placement Bachelor of Environment Policy and Management. - Community engagement and assistance in community climate survey.

Attachment C - High vulnerability indicator summary

High vulnerability indicators identified in the integrated vulnerability assessment. Indicators were relatively ranked as high, medium, or low based on their vulnerability score, where: Vulnerability = ((Exposure + Sensitivity) – Adaptive Capacity) + 10

THEME	HIGH VULNERABILITY INDICATORS
Assets and infrastructure	• condition of heritage assets (state or council owned) (built items)
Emergency management	• demand for emergency management services
Health and community vulnerability	• health, safety and wellbeing of low income households, people with a disability, low personal mobility and aged over 75 years
Industry/business in changing climate and markets	• regional economic contribution of the construction sector
Marine and coastal management	• condition and extent of natural coastal landscapes and the near shore marine environment, including mangrove forest, samphire and tidal mudflats and seagrass
Primary production	• productivity of field horticulture (carrots, lettuce, potatoes) • productivity of protected cropping horticulture (low technology poly tunnels)
Public open space	• amenity and character provided by open space and public realm • recreation opportunities provided by outdoor facilities including open and green space, playgrounds, walking and bike paths
Terrestrial biodiversity	• condition and extent of wetlands and riparian zone communities • condition and extent of terrestrial, native vegetation including forest, woodland and grassland
Urban planning and development	• effective functioning of residential housing • planning and building policy and controls that support sustainable (climate ready) development
Water management	• condition of surface water systems.

Attachment D - Adaptation options

The following table provides the full list of adaptation options identified for each of the key areas of decision making. Shown for each adaptation option is an assessment by workshop participants of whether the option is: currently occurring in the region and will be suitable in its current form for adaptation (current); currently occurring but will require some alteration to be suitable for adaptation (altered), or is not currently occurring in the region but should be implemented to facilitate adaptation (new). NB. Not all options were assessed as to whether they were current, altered or new.

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
Adaptive economy	**1.** Establish backup power and generators for businesses and key infrastructure (e.g. water, sewer and telecommunications).	✓	✓	
	2. Implement risk and opportunity assessment to inform investment prioritisation		✓	✓
	3. Brand and promote Northern Adelaide Green industries, products and services			✓
	4. Avoid construction of business facilities buildings in high risk areas	✓	✓	
	5. Consider changes to employment conditions during heatwaves (OH&S) (e.g. change in start/finish times as per contract)	✓		
	6. Improve access to renewables and storage technology (e.g. on-site or precinct-based solar, wind, biofuels and grid based power purchase agreements) that reduce electricity costs	✓	✓	✓
	7. Investigate options for attracting a diversity of businesses that reinforce the brand by promoting the region's resources (especially waste water)	✓	✓	
	8. Develop strategies to support businesses and build capacity in achieving efficiency in energy, water and use of other resources	✓		✓
	9. Demonstrate green industry and low carbon achievements in key projects		✓	
	10. Adopting waste to power technology amongst food producers			✓
	11. Address heat island to reduce micro climate where feasible - especially utilising recycled/waste water			✓

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
	12. Expand third pipe network to reduce demand on potable water supplies and increase proportionate use of recycled water	✓		
	13. Install smart metres region-wide to create as smart grid			✓
	14. Implement a governance structure that encourages improved irrigation practices to minimise overuse of recycled water and salinity build-up (e.g. Irrigation management plans, water sensors)			✓
	15. Establish an SA/Northern Adelaide food production 'brand' to be recognised globally			✓
	16. Increase investment in glasshouses for improved food productivity and water use efficiency			✓
	17. Explore further opportunities to build on new State businesses – Support for nuclear waste industry – e.g. Containment, containers, monitoring equipment - not actually having the waste dump here but have supporting industries.			
Climate-ready buildings	**1.** Relocate existing infrastructure and housing	·	·	✓
	2. Provide incentives for increased construction of “climate-ready” buildings including incentives for new technologies	✓	✓	✓
	3. Raise awareness about the benefits of climate-resilient buildings	·	·	✓
	4. Improve existing buildings using Building Upgrade Finance and solar incentives	✓	✓	·
	5. Identify barriers to implementing existing provision of the building code for climate-ready housing	·	✓	·
	6. Collaborate with the housing construction and development sector on low carbon sustainable urbanisation initiatives and partnerships.	·	·	✓
	7. Strengthen building requirements in new developments (residential, commercial	✓	✓	·

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
	and public assets) and mandate requirements (including evaluation)			
	8. Prepare guidelines on how to encourage greater use of climate ready building techniques, and site development and integrate with new planning Bill	·	✓	·
	9. Propose amendments to the development plan. Including stronger mandating of including 'climate-ready' policy	·	✓	·
	10. Better integrate building standards and planning regulations.	·	·	·
	11. Focus on retrofitting old buildings	·	·	·
	12. Efficiency of resources in buildings linked to whole-of-life and innovation in manufacturing.	·	·	✓
Coastal ecosystems	**1.** Continue and maintain modelling and mapping to assist with risk management	✓	✓	·
	2. Facilitate landward movement of mudflat and samphire areas (e.g. through relocating buildings and hard infrastructure)	·	✓	✓
	3. Investigate and implement engineering solutions (e.g. seawalls)	✓	·	·
	4. Investigate and implement land-use change solutions to minimise sediment and nutrient loads	✓	·	·
	5. Manage and restore connectivity to support migration and range shifts	·	·	·
	6. Minimise human-induced non-climatic stressors	·	✓	·
	7. Favour land-use changes with positive rather than negative biodiversity outcomes	·	·	✓
	8. Identify, manage and protect refugia	·	·	·
	9. Create and maintain reserves with hard boundaries	✓	·	·
	10. Restore and maintain coastal and marine habitats (e.g. Sea grass beds, samphire, mangroves)	✓	·	✓

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
	11. Initiate blue carbon projects to utilise coast and marine habitats to enhance blue carbon economy	·	·	✓
	12. Ensure resourcing for commercial fishery adaptation for potential changes in marine species and habitats to maintain a sustainable fishing industry and food resources	·	·	✓
	13. Promote coastal and marine nature based tourism opportunities	·	·	✓
	14. Invest in research and innovation for coastal wetlands restoration and management	·	✓	·
	15. Require ecotourism operators to contribute to management of tourism assets	·	·	✓
Extreme events and emergency management	**1.** Facilitate increased volunteerism including volunteer training	✓	✓	·
	2. Create buildings and infrastructure that are resilient to extreme events via improved planning policy, building codes and new materials	✓	✓	·
	3. Enforce section 104 notices regarding clean-up of land and fuel load	✓	✓	·
	4. Improve community awareness of, and preparation for hazards	✓	✓	·
	5. Establish and implement early warning systems for flood and fire	·	✓	·
	6. Identify areas where housing should not be located due to high risk, difficulty to access etc.	·	✓	·
	7. Develop real-time monitoring and surveillance of heat event impacts (often data related to heat related mortality is slow to be released and causes of death are attributed to other primary causes)	·	·	✓
	8. Raise local community ownership and awareness of risks and impacts. E.g. Land management Agreements on vulnerable sites flagging inundation risk	✓	✓	·
	9. Identify local risks and local responses (may be specific to a small area)	✓	✓	·
	10. Learn from previous incidents (both local and interstate)	·	·	·

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
	11. Ensure Council/Regional Emergency Response Plans are in place and current	·	·	·
	12. Ensure each Council has their own Business Continuity Plan in place	·	·	·
	13. Establish community refuges for extreme weather (e.g. heat) events	✓	✓	·
Health and safety of vulnerable people	**1.** Implement and enhance heatwave response services (e.g. Telecross REDi service and Council service through HACC)	✓	✓	·
	2. Scope potential Government responses relating to provision of heat refuges	·	·	✓
	3. Provide support for not-for-profit organisations or other service providers to vulnerable members of the community.	✓	✓	·
	4. Make available various transport options for people to access heat refuges	·	✓	✓
	5. Facilitate increased participation in community activities to build social capital (connectivity and resilience)	✓	✓	✓
	6. Amend development plan policy that prevents construction of community facilities in high risk areas	·	·	✓
	7. Adopt more climate-sensitive building designs	✓	✓	✓
	8. Install back-up power supplies to offset the impacts of strategic power outages by electricity distribution companies	·	✓	✓
Horticulture – Northern Adelaide Food Bowl	**1.** Investigate improvements in rules for water allocation, harvesting and trading	✓	✓	·
	2. Research and implement farming of different types of crops	·	✓	·
	3. Ensure continuity of electricity supply and telecommunications	✓	✓	✓
	4. Improve water use efficiency	✓	✓	✓
	5. Consider soil and salinity management strategies	✓	✓	·
	6. Improve prices through market development, branding and promotion including through increased coordination and cooperation	✓	✓	·

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
	7. Diversify farm production (e.g. aquaculture)	·	✓	·
	8. Use alternative water sources (e.g. desalination of drainage water or saline ground water)	✓	✓	·
	9. Increase the speed of land use planning policy amendments	✓	✓	·
	10. *Greenhouse Development, clusters, intensive food production systems adaptable to new technology*	✓	✓	·
	11. Better enable adoption strategies for new technologies	✓	✓	·
	12. Develop better training and communication support (including language support)	✓	✓	·
Natural landscapes	**1.** Manage, restore and monitor connectivity to support migration and range shifts (happening in Hills - not Plains)	✓	✓	·
	2. Minimise human-induced non-climatic stressors	·	✓	·
	3. Identify, value and manage ecosystem services	·	✓	·
	4. Continue to include 'local species' in plantings	·	·	·
	5. Introduce non-local native species using the proximity principle	·	✓	·
	6. More intensively manage fire regimes at site and landscape scales to favour desired trajectories resulting in biodiversity and community benefits	·	·	✓
	7. Consider and prepare for transitions in vegetation communities	·	✓	·
	8. Manage across boundaries and agencies for migration and range shift	·	·	✓
	9. Increase education of community on natural land scapes - culture trumps strategy	·	✓	·
	10. Re-evaluation of native species (local and non-local) for resilient environments	·	✓	·
	11. Development Planning to incorporate positive biodiversity outcomes	·	·	✓
	12. Compulsory land acquisition for bettering/developing biodiversity corridors	·	·	✓

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
Public open space and recreation	**1.** Make design allowances for increases in extreme events	·	✓	·
	2. Develop appropriate planning policy	·	✓	·
	3. Rationalise irrigated open space in order to maintain a smaller amount to a higher standard, including identifying opportunities to share facilities and the potential for artificial surfaces.	·	·	·
	4. Prepare 'climate-ready' guidelines regarding open space management including appropriate material and species selection, decrease grassed areas, increase planted areas, shade cover, root barriers for shade trees near built assets, consideration of needs as use changes (e.g. more lighting for evening activity) and diversification of use	·	✓	·
	5. Research, educate and implement stormwater management features to maximise amenity and potential for water reuse (e.g. MAR, swales), divert runoff without flooding built assets and permeable paving	✓	✓	·
	6. Investigate innovative techniques for cooling public realm (e.g. solar fans, cooled bus stops, shading techniques and wall gardens).	·	✓	✓
	7. Plant more trees in urban areas, with a focus on vulnerable community hotspots (ensuring appropriate species selection)	·	✓	·
	8. Increase community education on the benefits of sustainable water management for the environment (E.g. through WSUD)	·	·	·
	9. Undertake whole-of-life cost benefit analysis of WSUD in Northern Adelaide context	·	·	·
	10. Raise community awareness regarding climate change	·	·	·
	11. Increase development of connected green and blue spaces and corridors, including wetlands, streetscapes, reserves and sporting fields	·	✓	·
	12. Increase education on climate change adaption through suitable private open space design	·	✓	·

THEME	ADAPTATION OPTIONS	CURRENT	ALTERED	NEW
	13. Increase tree planting to develop greater shade within community	·	·	·
Water dependent ecosystems – constructed wetlands	**1.** Implement pest plant and animal control including source control (e.g. industry awareness regarding not selling pest species)	✓	✓	·
	2. Identify, protect and develop corridors to enable species migration (e.g. working streetscapes, enhanced water corridors, linked plantings etc.)	✓	✓	·
	3. Protect isolated patches of native vegetation and provide additional buffers; need to expand scope. Isolated patches might not be enough in the face of climate change.	✓	✓	·
	4. Support landholders managing native vegetation on private properties	✓	✓	·
	5. Identify, manage and protect refugia	·	·	✓
	6. Consider landscape engineering solutions (e.g. WSUD)	✓	·	·
	7. Integrate ecosystems with surrounding landscapes and communities	✓	✓	·
	8. Undertake strategic revegetation and/or rehabilitation in cleared/degraded areas	✓	·	·
	9. Enhance Sediment management, especially for high/extreme events and from upstream development	·	·	✓
	10. Economic 'tipping points': when to invest, when is the cost too high	·	·	✓
	11. Consider land availability for future constructed wetlands	·	·	✓
	12. Identify thresholds for water quantity and quality based on local catchments and objectives			
	13. Implement Regional Stormwater Management Plan across Council areas			
	14. Construction of stormwater infrastructure in line with SMP			