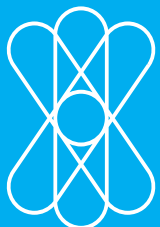


Learning from regional climate analogues



NCCARF
National
Climate Change Adaptation
Research Facility

Synthesis and Integrative Research Program

Learning from Regional Climate Analogues

Final report October 2011

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Published by the National Climate Change Adaptation Research Facility 2011

ISBN: 978-1-921609-41-1 NCCARF Publication 1/12

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Please cite this report as:

Kellett, J, Ness, D, Hamilton, C, Pullen, S & Leditschke, A 2011, *Learning from regional climate analogues*, National Climate Change Adaptation Research Facility, Gold Coast, 166 pp.

Acknowledgement:

This work was funded through the National Climate Change Adaptation Research Facility, which is an initiative of, and funded by the Australian Government Department of Climate Change and Energy Efficiency, with additional funding from the Queensland Government, Griffith University, Macquarie University, Queensland University of Technology, James Cook University, The University of Newcastle, Murdoch University, University of Southern Queensland and University of the Sunshine Coast.

The role of NCCARF is to lead the research community in a national interdisciplinary effort to generate the information needed by decision-makers in government and in vulnerable sectors and communities to manage the risk of climate change impacts.

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ACKNOWLEDGEMENTS

The research team wishes to acknowledge all those who kindly assisted with this project, and to thank them for their frank and helpful comments, advice, support and time.

Firstly, we wish to thank those associated with the National Climate Change Adaptation Research Facility (NCCARF) for their support and encouragement, especially Prof Jean Palutikof, Director; Dr David Rissik, Deputy Director/General Manager; and Mr Frank Stadler, Research Coordinator.

Dr John Higgins of the Dept of Climate Change and Energy Efficiency (DCCEE) kindly travelled to Adelaide to attend a Mid-Term Workshop.

We also wish to thank those from the various states who attended interviews and workshops, some travelling considerable distances, and provided frank and constructive comments, all on a voluntary basis.

We appreciate Port Pirie Regional Council (SA), Dept of Health (WA) and Moreton Bay Regional Council (Qld) for hosting the final workshops in their respective states.

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EXECUTIVE SUMMARY

This twelve-month study was commissioned by the National Climate Change Adaptation Research Facility (NCCARF) to examine the potential for Learning from Regional Climate Analogues through selected target communities in Australia. The underlying assumption is that communities reflect their prevailing climate in the way that they organise their infrastructure, built form and services, such as health and emergency response. Climate is also likely to dictate, to some extent, the policy content in development, infrastructure and health plans and the management of ecosystem services. Analogue/target pairings were selected for three states as shown below.

Target	State	Analogue (Community currently experiencing the climate which is predicted for the target)
Brisbane	Queensland	Gladstone
Bunbury	Western Australia	Geraldton
Adelaide	South Australia	Whyalla and Port Pirie

In Queensland, Gladstone was chosen as an analogue for Brisbane, and in Western Australia, Geraldton was the selected analogue for Bunbury. In South Australia, two communities, Port Pirie and Whyalla, were combined to provide the analogue for Adelaide. All pairings were based on the existing climate of the analogue being a reasonable match for the predicted climate in the target community in 2050. The fundamental aim was to develop a framework for analysis, and test this to determine whether a further, more detailed second stage of research (Part Two), would be likely to provide useful results. The analysis firstly examined policy documents across a range of sectors, namely: land use planning, infrastructure, housing and building, health services and ecosystem services. It sought to identify all current policy vehicles and extract from these the main aspects which may be viewed as a response to various climatic factors. The factors were heat, drought, bushfire, high wind velocity, flooding and coastal issues, such as storm surge and rising sea levels. Interviews with a range of stakeholders from local government and state agencies were conducted between November 2010 and February 2011. These added a useful extra layer of information about the main issues which the different analogue and target locations were facing, and their perceptions of the influence of climate on their policy decisions and working arrangements. This data was then analysed using a matrix-based approach to compare policy aspects with climate factors and identify whether potential for learning from analogues by targets existed. The matrix analysis identified a number of potential areas where analogues appeared to be responding differently to climatic factors from target communities. A series of workshops with stakeholders in each state were then held in April and May 2011 to test the findings. Overall, the analysis suggests that the approach does not clearly demonstrate a large range of easily discernible differences and the potential learning for target communities from analogue practice. The analysis demonstrates that state-driven policy in areas such as land use planning and health tends to result in similar policy response, in both analogues and targets. In some instances local policy makers are frustrated by this situation but have little power to change it. The status of policy, as reorganisation of government takes place and new plans are introduced, complicates the picture and interpretation of whether policy is more advanced in certain areas and was contested in the workshops. Nevertheless,

some examples of differing practice and approaches to common problems were identified. These are highlighted in boxes in the report. These differences were prominent in standards applied to the construction of houses and buildings, floodplain management, coastal policy, certain infrastructure services and health programs. These latter differences may be a function of different perceptions of risk, access to resources or differing population demographics. Further research would be needed to clearly identify the reasons for different responses to similar issues. The findings suggest that there are several potential opportunities for further research, which flow from and build upon the findings of this study. These opportunities particularly focus on governance and address questions about the relative benefits of top-down or bottom-up policy making.

1 BACKGROUND

1.1 THE CLIMATE CONTEXT

Humans are the only species on earth capable of adapting to life in almost every terrestrial environment. Settlements, and the communities which inhabit them, inevitably display an adaptive tendency to accommodate and respond to the prevailing climate. Thus, the housing technology, transport, diet and social customs of arctic communities are fundamentally different from those of rainforest or desert communities. Globalisation, advanced technology and specialisation of economic function tend to mask these differences to a great degree. Similarly, we might not expect to observe such marked distinctions between communities located in similar cultures and climate zones. Nevertheless, in Australia, a country of climatic extremes, which experiences at different times and places low rainfall, cyclones, flooding, storm surges and extreme heat, it is reasonable to expect to see some level of adaptation to these climatic conditions. Some of these adaptations may represent best practice solutions. Others may represent maladaptation. The pervasive influence of technology, such as mechanical airconditioning and long distance transfer of water resources, may imply that communities are adapting to climatic conditions in unsustainable ways, utilising energy and natural resources which they can ill afford, both financially and environmentally. On the other hand, the development of energy and water efficiency solutions in buildings, landscaped spaces and agriculture may represent valuable adaptations which assist in improving the sustainability and resilience of communities to climate conditions such as drought and extreme heat. The capacity and extent of human settlements to adapt to and live in harmony with their prevailing, and in the Australian context often uncertain, climate, forms the context for this report.

1.1 LEARNING FROM REGIONAL ANALOGUES

This project explores the potential of learning from experience for selected target cities by the study of analogue settlements which are currently experiencing climate conditions similar to those predicted for the target cities. The title of the project, *Learning from Regional Analogues*, flows from the fact that in each case the analogue/target pair is located in the same Australian state. The research focuses on developing relationships between paired climate target/climate analogue locations for sharing experiences and knowledge, leading to the possible development of a wider national network. It attempts to assess differences in natural and built systems and relate these to institutional policies, plans and processes for the paired locations. A key aim is to assess, through the application of a robust methodology of analysis, which policies and policy differences are a function of climate.

We have attempted to examine policy as it is currently framed and address whether it incorporates climatic factors. In a number of instances, policy is in a state of transition. For example, in Queensland following recent local government reform and a relatively new Planning Act, local councils are actively preparing new plans. We chose to use existing statutory policy in every instance, giving less weight to new, but as yet informal, policy documents. Therefore, this report inevitably provides a brief snapshot of current policy between late 2010 and the first half of 2011. A significant issue raised by a number of people interviewed as part of the study concerned the distinction between explicit and implicit consideration of climate. Many land use plans, for example, contain policies which are a response to hot weather. Policy requiring planting of shade trees is a good example. In most cases these policies are not supported or justified by any discussion of hot weather, heat waves or solar intensity, so the underlying logic for their inclusion may be viewed as implicit. Nevertheless, in the report we have included these as examples of climate driven policy. Overall, the report assumes that policy in respect to climate factors is simply a response to prevailing circumstances, and it may not explore the underlying reasons for policy choices. Nevertheless, the growing formal recognition of the risks which a changing climate brings about, is likely to produce more explicit discussion of climate in policy documents.

1.2 PROJECT METHODOLOGY

The project recognises that many institutions are already considering the impact of climate change on their planning and services, as well as their adaptation and resilience. However, the pairing of institutions within target locations with analogues representing their future climate might enable institutions within target locations to learn from the actual experiences and adaptation of their analogues, including from spatial and physical examples. However, what is not understood is whether it is possible to identify differences in policy and practice, derived from differing climates, between the analogue/target pairings. The project was commissioned by NCCARF to investigate the usefulness of the *Learning from Regional Analogues* concept. The essential aim of the current report is to develop a methodological approach and test the concept.

The specific objectives are:

- from an analysis of climate data, to identify a series of target urban locations subject to climate change, with matching locations that represent reasonable analogues for the future climate and its impacts within target locations, having regard to temperature, rainfall, extreme weather events etc, and to identify other characteristics of analogue/target locations (e.g. built/natural systems, demographics)
- to identify policies, plans and processes within the target urban locations that are climate related and address current and future impacts of climate change, and to document how analogue locations are currently responding to climatic factors through their policies, plans and processes, with actual examples of their past and present experiences
- to develop a methodology, including evidence-based case studies, that will clarify to what extent aspects of the above policies, plans, processes and characteristics are climate driven and which are subject to other influences
- to compare the current and projected future policies and approaches of the target locations with the analogues, so that any differences and gaps may be identified
- from the analysis of comparative data, and using risk management methodology, to depict the extent of adaptation required by the target locations and any necessary changes to policies, plans, processes and standards, with a focus on the areas of land use planning, infrastructure, housing, health and ecosystem services
- to present the findings in a form that may be easily understood and used by decision-makers, not only within the target and analogue locations, but also more widely.

1.2.1 Justification for selection of target/analogue pairs

For the purpose of this project, which was to prove the concept of learning from a climate analogue, an analogue was deemed suitable for analysis if its current climate is similar to the projected future climatic conditions of a corresponding target. It was decided that the selection of pairings should be geographically similar, and, if possible, in the same state jurisdiction, both to simplify the engagement process with stakeholders and minimise policy variations. Available scientific climatic data from the Bureau of Meteorology (BoM) and CSIRO climate projections was utilised for assessing each location, as well as its geographic location on the continent. Projections to 2030 and 2070 were used in each case study based on studies undertaken by CSIRO (2007), the Western Australian Department of Health (2008) and the Queensland Government (2009). Table 1 summarises the climatic data that has been compiled and analysed in determining target/analogue pairs. The key climatic variables which were considered of importance included:

- Temperature: mean maximum (°C), mean days > 35 °C & daily extreme high temperature (°C)
- Rainfall: annual average (mm), extreme daily (mm)

- Wind: maximum gust (kph)
- Humidity: mean relative 9am-3pm (%)

In each case, the projected conditions in the target location were compared with existing conditions in a number of potential analogue locations, and then classified as either a 'good', 'moderate' or 'poor' comparison in order to decide an appropriate pairing. As similarity in geographical location was important for consideration of sea level rise, storm surge and other coastal climatic factors, coastal targets needed to be paired with coastal analogues.

Using the projections for Adelaide provided by the CSIRO, the future projections for Adelaide in 2070 were best satisfied by the northern Spencer Gulf area of South Australia. Thus, two analogues – Port Pirie and Whyalla – were selected for comparison. The Port Pirie area is located on the eastern side of Spencer Gulf, with the Flinders Ranges located to the area's east. This is geographically similar to Adelaide's Mount Lofty Ranges. Whyalla was included to determine the extent of any difference in policies and plans there might be between major industrial centres in the Northern Spencer Gulf area.

The data available for Brisbane was problematic, in that limited data was used by CSIRO (1971 to 2000) to predict temperature extremes, and the predicted range of mean days > 35 °C is very broad. There are also inconsistencies in projections – the 50th percentile and range (10th and 90th percentiles) for 2030 and 2070 in climate change projections for the Queensland Government (2009) differ from the estimations of CSIRO (2007). This study also relied upon an uninterrupted data range in order to achieve a reliable understanding of the area's historical climate. Thus, the data for Brisbane, which was utilised for assessment, was collected from the Archerfield Airport, rather than the more recent Brisbane or Brisbane (Aero) sites.

The BoM data available for most regional centres were analysed using the projections for future climate for Western Australia (Department of Environment and Conservation, 2010). Temperature increases and rainfall reduction were drawn from the worst case scenario for South West WA: 2.1 deg C and 20% reduction in rainfall (2030) and 6 deg C and 60% reduction in rainfall (2070). The analysis of climatic data led to the pairing of Geraldton as an analogue for Bunbury.

As this study was undertaken to test a conceptual approach which may be researched further if found to be useful for assisting communities to adapt to climate change, a decision was made to select only a representative part of the metropolitan region within both Adelaide and Brisbane to reduce the data collection required in the short timeframe available for the project. In seeking agreement for each analogue and target pair, the City of Playford and City of Port Adelaide Enfield were used as representative target communities for Adelaide and the Moreton Bay Regional Council was the target community representing Brisbane. The final target and analogue pairs for SA then became Playford and Whyalla; Port Adelaide Enfield and Port Pirie; for Queensland, Gladstone and Moreton Bay; and for WA, Geraldton and Bunbury. Agreement was obtained from the Chief Executives of each local government authority to participate in this research project prior to any interviews and data collection or analysis. These pairings attempted as far as possible, to meet not only the climatic considerations of the research, but to match like with like in respect to other aspects of the communities studied. Thus, Playford was chosen as a suitable analogue for Whyalla because of its large scale industrial economy. Port Adelaide matched Port Pirie in respect to its coastal location and propensity for flooding. Moreton Bay was chosen as a pair for Gladstone because of its socio-economic profile. However, given the constraints of meeting the specified climate parameters for the study, it was not possible to match the communities in respect to every factor. Population size is a case in point, with significant differences between, for example, the size of Gladstone's population as compared to Moreton Bay, though Geraldton and Bunbury represent the best match in terms of overall coverage of factors.

1.2.2 Policy Analysis

The review of policy which constitutes the majority of this report seeks to identify policy vehicles and specific policy statements within them, which explicitly suggest that climate is a driver of policy or imply that climate has driven policy development. These are taken to be evidence of adaptation to climate in policy. There are three ways in which organisations may demonstrate adaptation actions in the report, namely:

- acknowledgement of potential climate-related hazards and risks in policy documents
- expressions of intent to implement a management response or particular management option
- actual implementation of particular policy or measure.

These are treated as being of equal importance.

Table 1 Comparison of climate data for various sites Target/Analogue Pairs

City (BoM Monitoring station)	Mean max temp deg C (2030/2070*)	Mean days > 35C	Annual Rainfall mm (2030/2070)	Extremes High daily temp deg C	Extremes High daily rainfall mm	Max wind Gust km/hr	Mean rel. humidity % 9am/3pm	Data range Yrs (# yrs)	Fit as analogue?
Adelaide (Kent Town) SA	22.3 (23.5/25.8)	19.9^ (25.5/46.6)	542 (482/368)	45.7 in Jan 2009	55 in Oct 1997	102 in Dec 1986	62%/47%	1977 to 2010 (33 yrs)	Target 1
Port Pirie (Nyrstar Comparison) SA	24.5	34.5	344	46.3 in Jan 1979	125 in Dec 1979	NR	63%/47%	1877 to 2010 (133 yrs)	Analogue 1
Adelaide (Parafield) SA	22.3 (23.5/25.8)	21.9	451	46.4 in Jan 2003	83 in Oct 1997	141 in Nov 1948	64%/48%	1929 to 2010 (81 yrs)	Target 2
Whyalla (Norrie) SA	23.6	27.7	288	47.3 in Jan 1982	58 in June 2001	NR	67%/47%	1906 to 2001 (95 yrs)	Analogue 2
Whyalla (Aero) SA	23.7	28.3	264	48.0 in Feb 2009	101 in Feb 1979	NR	64%/44%	1945 to 2010 (65 yrs)	Analogue 2
Brisbane (Archerfield Airport) Qld	26.2** (27.5/30.2)	4.7^ (2.5/20.6)	1062 (934/711)	43.3 in Jan 1940	343 in Feb 1931	143 in Dec 1946	67%/51%	1929 to 2010 (81 yrs)	Target 3
Brisbane Qld	26.5 (27.8/30.5)	3.8^	894	41.7 in Feb 2004	138 in Mar 2001	NR	63%/52%	1999 to 2010 (11 yrs)	(in Brisbane metro area)
Brisbane (Aero) Qld	25.4** (26.9/29.4)	1.2	947	40.2 in Feb 2004	176 in May 1996	121 in Dec 2002	64%/58%	1992 to 2010 (18 yrs)	(in Brisbane metro area)
Brisbane (Regional Office) Qld	25.5** (26.8/29.5)	3.5^	1149	43.2 in Jan 1940	465 in Jan 1887	145 in Jan 1985	66%/53%	1840 to 1994 (154 yrs)	(in Brisbane metro area)
Gladstone (Radar) Qld	27.7**	4.4	879	42.0 in Mar 2007	248 in Feb 2003	156 in Jan 1976	67%/59%	1957 to 2010 (53 yrs)	Analogue 3
Bunbury (Post office) WA	21.8 (23.9/27.8)	3.7	870 (696/348)	40.9 in Jan 1980	417 in July 1878	NR	72%/63%	1880-1985 (105 yrs)	Target 4
Bunbury WA	22.9 (25.0/28.9)	9.8	726 (580/290)	40.6 In Jan 2010	264 In July 2000	NR	69%/55%	1995-2010 (15 yrs)	Target 4
Geraldton WA	25.8	35.9	448	47.7 In Jan 1954	287 In June 1945	143 In June 1973	61%/50%	1941 to 2010 (69 yrs)	Analogue 4

Notes – for Table 1

Sources: BoM 2010 Climate data online. Bureau of Meteorology <http://www.bom.gov.au/climate/averages/index.shtml> as at 24 May 2010; NR=Not Recorded; * Highest of range predicted i.e. 90th percentiles; ** These numbers are higher than average used for modelling, which was 19.4°C for SE Queensland and 23.3°C for Townsville; # uses 0.5°C to 2°C as range as per WA Health Impacts of Climate Change Report http://www.public.health.wa.gov.au/cproot/1510/2/Health_Impacts_of_Climate_Change.pdf accessed 25 May 2010; ^CSIRO 2003 report (McInnes et al 2003) for SA indicates days over 35°C for Adelaide were 14; and CSIRO 2007 Appendix B City Summaries also has some different figures for days over 35°C due to limited years for which data was used (1971 to 2000) – Adelaide: 17.0, Brisbane: 1.0, Melbourne: 9.1, Perth: 28. Projections for WA South West are from WA DEC (2010) Climate Change Science 'Our Climate is changing' <http://www.dec.wa.gov.au/content/view/5172/2189/1/1/> viewed 12 Nov 2010 [Temp increase and rainfall reduction from worst case scenario for South West WA: 2.1 deg C and 20% reduction in rainfall (2030) 6 deg C and 60% reduction in rainfall (2070)]

1.3 METHODS OF DATA COLLECTION AND ANALYSIS

In determining the methods for data collection and analysis, consideration was given to both the timeframe available for data collection and the people and financial resources available to the project team. In the initial stages of the project design, the South Australian Department of Premier and Cabinet climate team were consulted for advice on potential government contacts within South Australia and interstate, and on the general concept of the project. In determining the methods for data collection, and following discussion with NCCARF Project officers, a phased approach was agreed upon whereby a method of data collection would be trialled for the South Australian pairings, then reviewed for data collection in Queensland and Western Australia.

In establishing the scope of the project to identify and analyse the policy response to climatic factors, five aspects of the natural and built form of communities have been studied. These are:

- land use planning
- infrastructure
- housing and building
- health services
- ecosystem services.

For each of these five aspects, the climatic factors which may affect policies and plans for delivering these services at the local level were identified as:

- heat
- drought
- bushfire threat
- high wind velocity
- flooding/intense rainfall
- coastal factors.

The five aspects are further defined in Section 1.4.1 and the six climatic factors are defined in Section.1.4.2. It should be noted at the outset that a large range of factors apart from climate are responsible for policy formulation. This analysis attempts to identify evidence of climate in policy drivers by identifying policy which explicitly discusses climate or is clearly driven by climatic concerns, but it does not attempt to explain the entire range of policy drivers, which is undoubtedly much more extensive.

1.3.1 Definition of Aspects

LAND USE PLANNING

Land use planning is a government function which aims to achieve the orderly and sustainable use of land. It is concerned with a broad range of aspects relating to the development and use of land. The definition of these aspects may be more or less extensive depending on the governance arrangements and distribution of departmental responsibilities in the relevant jurisdiction. It often relates to, and overlaps with, infrastructure planning and natural resource management functions. Since it is intrinsically concerned with urban development, land use planning has clear concerns with new building and housing development, but increasingly the concerns of land use planning and building regulation are becoming separate and more closely defined in policy and regulation. In most jurisdictions, land use planning is carried out at two

distinct levels of government. Strategic planning examines broad issues relating to land allocation for development based on demographic, economic and other trends. Local planning tends to be more detailed and location specific and usually takes place within the frameworks set by higher levels of strategic planning. In Australia, state government usually plays an overarching strategic role; local government normally deals with local land use planning. Often, local planning forms the statutory level against which applications for development approval are assessed. Local land use plans used for this purpose vary in scope and content between state jurisdictions. The underlying approach to planning regulation may also vary with regulatory planning frameworks such as those in South Australia, seeking to set quantifiable standards for many aspects of development and performance based systems, such as those in Queensland, setting out objectives which developments should seek to achieve without specifically defining how this should be done. A common aspect is that all applications for development should be assessed primarily against the provisions of the relevant statutory land use plan.

INFRASTRUCTURE

In this study, infrastructure includes 'hard' infrastructure such as water supply, stormwater drainage, waste management systems, energy systems, transport systems (including rail, roads and ports), coastal protection devices and community facilities, such as sporting facilities and grounds. However, it excludes other 'soft' infrastructure such as education and similar social infrastructure. Infrastructure is viewed not only in terms of pipes, wires and drains themselves, but also in how it supports water, energy, transport and other services. In this regard, it is important in underpinning the economic base, functions and resilience of communities and in supporting national, state and regional economic development strategies. Nationally important infrastructure is overseen by Infrastructure Australia and bodies such as the Australian Rail Track Corporation (ARTC). In most jurisdictions, infrastructure planning is carried out within the overall context of state, regional or local strategic plans, economic development plans and land use planning strategies. Thus, it often overlaps with land use and demographic planning and, in relation to water and drainage infrastructure, with natural resource management functions. For example, large mining and industrial projects, which generate economic development and employment, will depend upon energy, transport and water infrastructure. In turn, the demand for water and water infrastructure may impact upon the natural resources and groundwater. This may be reduced by the judicious reuse and treatment of waste water and storm water. In the context of recent natural disasters, infrastructure also plays an important role in emergency management and planning for natural disasters, such as in communications, levees and coastal protection. Again, there is a link with natural resource management, as coastal setbacks and natural buffers are an alternative to hard engineering coastal defences. Infrastructure – including coastal engineering infrastructure such as groynes, sea walls, levees and the like – is usually very costly and long life, often being designed for a life of 50 to 100 years, with related design standards. Because of its strategic nature, infrastructure planning needs to encompass issues such as maintenance and replacement, but also the requirement for additional or reconfigured infrastructure to provide for the needs of growing communities, industry and agriculture.

HOUSING AND BUILDING

Housing and building refers to residential and non-residential construction developments, the performance of which must comply with current standards. Minimum standards for building design and construction are regulated by means of the Building Code of Australia (BCA), now also referred to as the National Construction Code (as of 1st May 2011). Acting on behalf of the Australian, state and territory Governments, the BCA is produced and maintained by the Australian Building Codes Board (ABCB). The aim of the BCA is to enable the achievement of nationally consistent standards for buildings, with regard to structural safety, fire resistance, access and egress, health and amenity, and energy efficiency. As such, the BCA is a significant instrument in shaping the ability of buildings to provide minimum levels of safety, shelter and

comfort throughout the wide range of climates present in Australia. Regulations for houses are covered in volume 2 and for commercial buildings in volume 1 of the BCA. The recent inclusion of the Plumbing Code as volume 3 completes the newly formed National Construction Code. The BCA has evolved over the years and makes allowance for state based variations as appendices to the code. Each state and territory provides enabling legislation to bring into operation the BCA as building regulations. Conformance with the various aspects of the building regulations can be obtained either by using prescribed methods known as the deemed-to-satisfy provisions or by performance-based alternative solutions.

In terms of possible adaptations of buildings to climate change, it should be emphasised that many aspects of building design are based on the assumption that historical data of climate events are a valid predictor for the future. Clearly, models of climate change in the future suggest a greater incidence of extreme weather events and this assumption is now unlikely to be valid. In addition, certain areas of regulation have been made more stringent with time, for example, energy efficiency performance, which means that a large proportion of the existing building stock is below the current minimum performance standards. A further point is that the BCA is focused on individual buildings and not the surrounding areas or urban infrastructure. This means that other factors, including local planning policy and regulation, can influence the ability of buildings to function adequately in changing climate conditions.

HEALTH SERVICES

In this study, a health service is understood to be a service for maintaining, improving or restoring people's health and wellbeing. Health services may be provided at a hospital, nursing home, community health facility or other place; and include services for public health – the prevention and control of disease or sickness; the prevention of injury or the protection and promotion of health. Emergency services are also included in the definition of health services used in this study. Health services in Australia are generally the responsibility of state governments, with local government playing an important role in delivering public health services and coordinating emergency services in some jurisdictions. While each state has legislation to address the health of individuals and the community, legislated definitions or interpretations of health services are state specific.

ECOSYSTEM SERVICES

Ecosystem services are those services provided to humans by nature, largely free of charge and often unrecognised (Proctor et al 2002). They include: pollination; life fulfilment; climate regulation; pest control; genetic resources (ecosystem, species and genetic diversity); habitat; shade and shelter; water health and soil health. Some ecosystem services such as water and soil health and pest control are enhanced by the actions of natural resources management groups and programs while others, such as life-fulfilment, are less able to be managed through programs on the ground.

1.3.2 Definition of Climatic factors

Six climatic factors have been used to explore the extent to which policies, plans and programs for each community are providing evidence of taking climate into consideration in the natural and built environment used by communities. These are heat, drought, bushfire threat, high wind velocity, flooding/intense rainfall and coastal events. The use of these terms within this study is discussed in this section.

HEAT

In this study heat encompasses both high temperature and heat waves, which in some jurisdictions (eg Queensland) incorporates both heat and humidity. In climatic records, the number of days over 35 degrees Celsius each year is used as an indicator of a hot climate. The average temperatures in summer and winter are also useful in understanding the climate variations which may occur. Most heatwave events in southern Australia result from the confluence of three factors, all of which were present in the 2009 southern Australian heat wave event:

- high daily maximum and high daily minimum temperatures, leading to high daily average temperatures
- the reduced influence of the normal diurnal pattern of night-time cooling (reduced diurnal range)
- the persistence of these conditions over consecutive days, resulting in the absence of any real remission from heat stress (Queensland University of Technology 2010, p. 3).

DROUGHT

Drought has been defined as a 'prolonged absence or marked deficiency of precipitation', a 'deficiency that results in water shortage for some activity or for some group' or a 'period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance' (Heim, 2002). Agricultural drought relates to moisture deficits in the topmost 1 metre or so of soil (the root zone) that affects crops; meteorological drought is mainly a prolonged deficit of precipitation, and hydrologic drought is related to below-normal stream flow, lake and groundwater levels. A megadrought is a long drawn out and pervasive drought, lasting much longer than normal, usually a decade or more (IPCC 2007, p. 80). The variability in climate across Australia makes the definition of drought problematic and demands a consideration of local historical climate records. While drought maps are produced in Australia by BoM, highlighting areas considered to be suffering from a serious or severe rainfall deficiency, drought declaration is the responsibility of state governments which must consider other factors apart from rainfall. In this study, drought is discussed in terms of acute water shortage. When dry conditions are not relieved by equally wet periods over a number of years, or when a shorter dry period is exceptional, it is commonly called drought. Hence it is this common usage that is explored in this study, although policy may define drought in each jurisdiction.

BUSHFIRE THREAT

Bushfire threat is often related to climatic conditions, notably extreme or prolonged heat, lack of precipitation and wind strength and direction, though vegetation type, slope and aspect are all important factors which affect the level of threat in specific locations. The South Australian Country Fire Service defines a bushfire as an unplanned fire noting that it is a generic term that includes grass fires, forest fires and scrub fires (Government of South Australia, n.d.). Fires do not necessarily always start spontaneously and human influences can be important. Nevertheless, for a given set of conditions, the risk of bushfire is usually increased by the climatic factors noted above.

HIGH WIND VELOCITY

High wind velocity is defined as wind speed or strength that is significantly above that normally experienced in an area. Often this increased wind speed will take the form of wind gusts

associated with storm events, cyclones or tornadoes. The Beaufort scale is one of several methods used to measure wind ranging from 1 (Flat calm, < 0.3 metres per second) to 12 (Hurricane force, > 32.7 metres per second). Beaufort estimates that gale force 8 is equivalent to 17.2 -22.7 metres per second. For the purposes of this report, gale force 8 and above is taken to represent high velocity wind. For structural loadings a common measure is the three second gust which has a 1 in 50 likelihood of being exceeded in any year.

FLOODING/INTENSE RAINFALL

South Australian State Emergency Services define a flood as water inundating land that is normally dry. There are a number of flood causes, as set out below:

- short, intense bursts of rain which overwhelm drainage systems
- Flash floods often result when a storm moves slowly, so that a small area receives most of the rain. The drainage and runoff characteristics on the ground can also determine the area of greatest impact;
- Other causes of flash floods include dam failures or burst water mains.

Floods can take variety of forms, for example:

Slow-onset floods - flooding of river systems in the northern pastoral areas of South Australia can spread for thousands of square kilometres and last for many weeks. This can cause damage to road and railways with potential for loss of stock and isolation of settlements and homesteads. Flooding of the River Murray can last for many days or weeks and impact towns and agricultural industries situated in the flood plain.

Rapid on-set floods occur in steeper terrain such as the Mount Lofty Ranges and in rivers draining to the coast. These floods can be more damaging and pose a greater risk to life and property because there is less warning and much less time to take preventative and preparative action.

Flash floods pose the greatest threat to loss of life and can result in substantial damage to property. Increased building density in urban areas is increasing the likelihood of flash flooding because drainage systems can no longer cope with the velocity and volume of water run-off (Government of South Australia, 2010).

COASTAL

Coastal issues resulting from climate factors are storm surge and sea level rise. Sea level rise relates to progressive climate change affecting the oceans and is likely to take place over decades. Storm surge is a much more immediate issue. It is defined as an increase in coastal water levels well above the normal high tide. Storm surge is combined with daily tidal variation, the combined water level is known as the *storm tide*. While wind and pressure are responsible for generating sea level extremes, factors such as coastal geometry and width of the continental shelf play a role in determining the relative contribution by waves and storm surge. Wide shallow continental shelves produce large storm surges, while a narrow continental shelf, like the central east coast of Australia, will produce large waves (Helman et al. 2010, p5).

1.3.3 Data collection

Data was collected using a desktop study supplemented by interviews. An internet search identified relevant policies, plans and programs for each location and at regional and state levels. After compiling climate data, policies, plans, processes and physical characteristics of natural

and built systems, interviews were conducted in each location to identify how climate factors have been integrated into policies, plans and approaches, highlighting gaps. These interviews also introduced the project, explaining objectives, deliverables, timing and methodology. Identification of key persons to interview used a snowballing method whereby a key person from each state, in government, a local government association or known to NCCARF would suggest appropriate persons to then interview. Data gaps were filled using follow-up face-to-face interviews or telephone conversations with relevant stakeholders as required. Interviews adopted a semi-structured format and questions were provided to interviewees prior to visiting each location. In each location, local government was asked to invite others from within the organisation or from the broader local or regional network to ensure a broad cross section of views and knowledge about local action that climatic factors may influence. Notes were taken by the research team and reviewed by attendees for accuracy and completeness.

1.3.4 Data analysis

Relevant policies, plans and programs or actions were analysed for inclusion of climatic factors that relate to each of the five aspects. Word searches through documents using key words or strings were utilised for electronic documents. Other documents in written form, including notes of interviews, were searched for evidence of how current climatic factors may have driven the development of specific policy, plans or services pertaining to each of the five aspects in each community. Overviews of policies and plans were developed by the research team for future reference. The data were then entered into matrices that address the six key climatic factors for each of the five aspects. The matrices were initially constructed for three levels of government, namely: state, regional or local. The extent to which each location in each pairing had already included climatic factors in developing policies, plans or services, was then determined by the experts within the research team who assigned a colour of varying intensity to indicate whether the policies or plans relating to this aspect fully address, partly address or do not address the climatic factor. The expert opinions are qualitative in the main and further research would need to be undertaken to quantify some of these findings – a potential objective of Part Two of this study. The examples where analogues are seen to be addressing climatic factors in a different or more extensive manner compared to the target have been developed into case studies, which have been highlighted in the final report as boxes.

1.3.5 Presentation of findings

Following analysis and preparation of preliminary findings, a closing workshop was held in each jurisdiction, seeking stakeholder feedback on the findings for the project and the feasibility of undertaking Part Two. The detailed matrices which summarise the policies, plans and program at the state, regional and local level were distributed to workshop attendees. The notes taken by the research team at the workshop and feedback provided by workshop participants have been considered in modifying the matrices and choosing colour schemes for presentation and discussion in this report.

In the proceeding sections, the findings for each analogue/target pairing in South Australia, Queensland and Western Australia are presented. After a description of the analogue/ target communities, the evidence for how climatic factors have influenced the development of policy responses, manifested itself in this study, is presented. At the end of each aspect, a matrix which summarises the qualitative (subjective) assessment of climatic factors by each expert is presented. At the end of each State Section, a matrix of reference documents and the climatic factor that the document pertains to, are also presented. Within Chapters 2, 3 and 4, there are boxes which are case studies detailing the policies, plans or approaches by which the analogue responds to specific climatic factors for that aspect and how the target community may be able to learn from the analogue.

The discussion of risk is incorporated in the Discussion and Conclusions (Chapter 5) followed by Reflections and Recommendations.

2 SOUTH AUSTRALIA

2.1 TARGET AND ANALOGUE PAIRS

Two analogue/target pairings were studied in South Australia. These are described in the following sections. Unless otherwise stated, all statistics are sources from the Australian Bureau of Statistics 2006 Census.

2.1.1 The Port Pirie Regional Council

Port Pirie, South Australia is located approximately 200km north of Adelaide. The Port Pirie Regional Council is 1761.8 km² in area. It is situated on the eastern side of the Spencer Gulf, in the South Flinders Ranges. The council area consists of the regional city centre of Port Pirie, as well as smaller rural towns, including Crystal Brook, Redhill, Koolunga, Wandearah, Mundoorra, Napperby and Warnertown (Port Pirie Regional Council, 2010a). In 2006, the total regional population consisted of 17,142 people. 21% of the population was aged between 0 to 14 years old, with 18.2% of the populace over the age of 65.

The key industries of the Port Pirie region include mining and mineral processing, agriculture and manufacturing and export. The Port Pirie integrated multi-metal refinery and lead smelter is the largest of its kind, globally, and is operated by Nyrstar Limited. The plant produces refined lead, silver, zinc, copper and gold (Nyrstar Limited, 2010), and provides employment for the region.

2.1.2 The City of Port Adelaide Enfield

The City of Port Adelaide Enfield, South Australia is located approximately 14km north-west of the Adelaide Central Business District (CBD). The council is 91.7 km² in area. It is considered one of the largest councils in area within South Australia. Extending from the Torrens River, to Outer Harbour, the council area contains the Port River to its west and Torrens and Garden Islands in its northern region (City of Port Adelaide Enfield, n.d.a).

In 2006, the total council population consisted of 102,928 people. 17.3% of the population was aged between 0–14 years old, with 15.3% of the populace over the age of 65. The City of Port Adelaide Enfield has a higher proportion of people who speak a language other than English at home, compared to Metropolitan Adelaide. For example, in 2006, 3.5% of the total population of the council were born in Vietnam, with 4.7% speaking Vietnamese at home (City of Port Adelaide Enfield n.d.b).

The key industries and economic base of the City of Port Adelaide Enfield region include: manufacturing (15.5% of the total population worked in this area in 2006); business, retailing, commerce and services; manufacturing and tourism.

2.1.3 The City of Whyalla

Whyalla, South Australia is located approximately 396km northwest of Adelaide and 73km from Port Augusta, and is the largest city in the Spencer Gulf region. Founded in 1901, Whyalla was established as a port 'to ship iron ore extracted from the nearby Middleback Ranges' (City of Whyalla, n.d.). Whyalla's urban area is approximately 41.5km².

The Whyalla City Council is 1032.5km² in area, and is situated on the western shores of the Spencer Gulf (City of Whyalla, n.d.) In 2006, the total regional population consisted of 21,416

people. 21% of the population was aged between 0–14 years old, with 13.6% of the population over the age of 65.

The key industries of the Whyalla region include: mining and mineral processing; higher education; aquaculture; agriculture and defence. The Whyalla OneSteel steelworks, located in Whyalla, is an expanding iron ore business in the area, providing substantial employment in the region. For example, the 5-year, \$350 million OneSteel 'Project Magnet' has extended the life of the plant until 2027, as well as increasing hematite iron ore exports. A Phase 2 of this project is in train. (OneSteel Ltd., 2010)

2.1.4 The City of Playford

The City of Playford, South Australia is located approximately 30km north of the Adelaide Central Business District. The council is 345.0km² in area. It is considered a 'rural and growing urban area' with 'some industrial and commercial areas' (City of Playford n.d.a) In 2006, the total council population consisted of 70,011 people. 22.7% of the population was aged between 0–14 years old, with 11% of the population over the age of 65.

The key industries of the City of Playford region include horticulture, manufacturing and motor vehicle processing. For example, according to the City of Playford statistics, horticulture in the region comprises '19,000 hectares (50% of land mass), (with) 4,000 hectares currently under production'. This results in 'over 60 products grown with a gross value of \$70 million per year' (City of Playford, n.d.b).

2.2 POLICY ANALYSIS

2.2.1 Land Use Planning

Land use planning in South Australia is carried out under the framework of *Development Act, 1993*. Strategic policy is published at state government level as the *30 Year Plan for Greater Adelaide* (Department of Planning and Local Government, 2010a) and outside of the metropolitan area, in the *Planning Strategy for Regional South Australia* (last updated 2007), which is currently undergoing review. Local councils, of which there are 68 in the state, are responsible for the preparation of local Development Plans (LDP) which cover detailed land use issues and must reflect the strategic priorities set out in the higher level plans. Responding to climate change has been recognised as a key aspect of strategic planning and as local council development plans are updated, this concern is beginning to be incorporated into this level of policy. Whilst the strategic documents noted above set the overall framework and devote space to climate change, noting it as significant policy issue, the *Development Act 1993* identifies Local Development Plans as the statutory vehicle against which development proposals are assessed. The following analysis therefore focuses on this level of planning policy. The state sponsored *Better Development Plans* project has standardised the format and wording of LDPs to the extent that Objectives and Principles of Development Control with exactly the same wording appear in numerous plans for different areas. Nevertheless, the inclusion of policy in certain plans and its absence in others provides the best evidence for analogue/target differences.

Port Pirie/Port Adelaide Enfield Pairing

In respect to the Port Pirie analogue, the Local Development Plan was approved in 2002 and has been subject to 16 subsequent amendments. The latest LDP was consolidated in 2011 (Department of Planning and Local Government, 2011). Most references to climate in the Plan relate to recognition of the need to respond to a changing climate. As a consequence, the plan contains general objectives relating to mitigation of climate change but has no general adaptation objectives.

Whyalla/Playford Pairing

In respect to the Whyalla analogue, the local Development Plan was consolidated in July 2010 following 19 amendments since 1997. The plan includes general policies which relate implicitly to climate adaptation mainly through the *Natural Hazards* section which includes consideration *inter alia* of flooding, bushfire, soil salinity and land slip hazard.

HEAT

There is little content within the Port Pirie development plan dealing with high summer temperatures. The incorporation of soft landscaping to reduce heat load in car parks is mentioned (p.17) as is the need to locate and design residential glazing so as to minimise heat gain in summer and enable heat gain in winter (p.39). The development plan contains frequent mention of the need to provide shading through planting in locations such as car parks, residential areas and for protection of livestock. The Port Adelaide Enfield (PAE) Development Plan contains similar provisions. There appear to be no policies in either plan which are relevant to dealing with heat waves. Concern was expressed in interviews at Port Pirie about the effects of direct solar radiation on public amenity space. Open space planning policy is currently being amended to incorporate shading into public parks either using planting or artificial devices.

Policy aimed at dealing with high temperatures or hot spells in the Whyalla Development Plan is contained in a range of policies which point to the benefits of design and planting to achieve summer shade (see pages 19, 53, 64, 65, 74, 80, 91, 154, 161). These policies are typical of South Australian Development plans and are almost identical in the Playford LDP. The impact of the built environment on heat was an issue of concern raised in interviews with Whyalla council staff (Interview, Whyalla City Council, 29 November 2010). The potential of increased residential densities, smaller allotment sizes and larger house footprints to increase urban heat island effects were noted as issues which would need to be addressed in future policy revisions.

DROUGHT

Port Pirie includes provisions in the LDP to encourage the reuse of storm water in new residential subdivisions and major developments. Whilst there is a concentration in the plan on adequate arrangements for drainage and disposal of storm water, policy also suggests that where practicable, scope for onsite storm water detention, retention and use including from roofs and car parks reuse should be encouraged. 45,000 litre rainwater tanks are also mandated for residential developments not capable of connection to reticulated supply. Because of possible lead contamination from local industry, the use of rainwater for drinking water is restricted. PAE also encourages stormwater capture and reuse (p. 57) as do many other metropolitan council plans.

Water supply has always been a problem for Whyalla with water being trucked into the town until 1943 when it was connected to the Murray by a pipeline. Whyalla's image as dry and dusty is also important in respect to attracting and retaining population. As industry and population grow, water is a crucial council concern. The Development Plan sets as a general objective that '*development should be designed to minimise consumption, maximise conservation and encourage reuse of water resources*' (p. 60). Furthermore, '*the rate of water discharged from a development site should not exceed the rate of discharge from the site in pre development conditions*' (p. 60). A similar policy is contained in the Playford Development plan (p. 65). Whilst residential design principles suggest that sufficient space should be allocated for water tanks (p. 73) there is no policy in either plan which demands their installation. Both Whyalla and Playford Council have been active in developing wetlands to retain stormwater and facilitate aquifer

recharge. Both recognise the public safety aspects of these policies including siting measures to restrict mosquito problems. Whyalla is notable for the number of dry land gardens utilising native plants which require no artificial watering. This appears to be an autonomous adaptation in response to low rainfall. The Development Plan does not contain any policies aimed at encouraging this type of planting in privately owned spaces. Policy relating to landscaping of public open spaces demands that it be designed to minimise maintenance costs and provide habitat for local fauna. Native planting not requiring irrigation therefore meets this policy.

BUSHFIRE THREAT

Port Pirie has designated a number of Bushfire Protection areas and has a comprehensive set of policies which deal with siting, design, access and protection of development in the different zones. These derive in part from state driven amendments to policy made in 2009 and 2010, so cannot be viewed as analogue responses which are in advance of target policies. The threat of bushfire is significantly less in PAE, but across metropolitan Adelaide there are numerous examples of development plans with provisions that are as comprehensive as those of the Port Pirie plan.

Comprehensive bushfire policies including maps showing areas of risk, siting policies, design and materials, requirements for water tanks for fire fighting and access arrangements for emergence vehicles are contained in both the City of Whyalla and City Of Playford LDPs in line with recent state wide policy revisions .

HIGH VELOCITY WIND

Dust from the lead smelter, which is located in the town centre, is a major policy concern in Port Pirie. Dust has also been a pervasive problem in Whyalla for many years, partly as result of its dry climate and partly as result of industrial emissions. The emissions issues in both cities are dealt with through environmental legislation outside of the scope of land use planning. A number of policy statements in the Development Plan relate to the potential for planting and landscaping to counter the effects of windblown dust. Any concerns relating to high wind gust impacts on buildings are the preserve of the Building Code of Australia and similarly lie outside of land use planning policy.

FLOODING/INTENSE RAINFALL

Intense rainfall is an issue that is not typically addressed in LDPs apart from in its manifestation as flooding. Structural issues relating to the ability of buildings to withstand heavy rainfall or hail are an issue for the Building Code of Australia.

A major concern of land use planning in Port Pirie is flood risk. The Port Pirie Township has been subject to five tidal inundation events in the past 100 years and is vulnerable to these events due to it being predominantly established on low gradient tidal flats. Whilst rainfall is unreliable in the Port Pirie region, the area is prone to significant flooding due to extreme weather events. Policy therefore demands that:

Development should only take place on land which is protected from flooding by higher land, tidal levee banks and stormwater drainage where the actual probability of water reaching to within 25 cm of floor levels is less than 1 percent, taking into account protection measures and an increase of 30 cm in mean sea level; and

Low lying land should not be zoned for development unless environmentally sound mitigation and protection works are formally and securely guaranteed by council or the proponents of development. Protection requirements need to be based on an anticipated sea level rise of 30 cm between 1991 –2050 and 70 cm between 2050 – 2100 (p.10).

Further policies restrict development with 50 metres of a river or stream and seek to protect the integrity of flood levees from damage or erosion. As a result of experience, development of land which risks being flooded is an issue which appears to be strictly controlled by the Port Pirie development plan. Interview evidence suggested that whilst these policies are important, their implementation is compromised by the recent introduction of a state wide residential code which may provide a loophole for developers to ignore the floor height requirements in such zones. Also, the lack of detailed survey evidence relating to precisely which areas are at risk may also mean council has inadequate hard evidence on which to base refusals of development consent. Port Adelaide is also an area of significant flood risk. Here a major research project has provided very high resolution mapping of flood risk, but policy in the development plans lags behind the analysis of risk. Port Adelaide Council recognises the need for a revision of policy to take the risk into account and raise the quality of policy to that of Port Pirie.

The policy response to flooding represents a case where the analogue may be in advance of the target in terms of policy development. However, the target has had access to significant resources to map flood risk, which the analogue now requires.

Whyalla suffered flooding from intense rainfall that inundated the airport runway and an adjacent housing area in the recent past. It also possesses significant areas of housing development which are vulnerable to storm surge. The Development Plan specifies that development should not take place in areas that are threatened by inundation by tidal, drainage or flood waters unless the 1 in 100 ARI can be satisfactorily dealt with by the stormwater system and buildings are designed to prevent entry of water. Similar policies are operational in the Playford Development plan and such policies are commonly found in other South Australian development plans.

COASTAL

Standard state coastal policies are present in the development plans for both Port Pirie and Port Adelaide. Both plans contain provisions to deal with the protection of the council from compensation claims arising from loss of private properties as result of storms and coastal erosion. In both cases these include policies relating to technical coast protection measures and/or financial guarantees (Port Pirie Regional Council, p.69, City of Port Adelaide Enfield, p.70). Both also include the requirement that:

Where there is inadequate area to provide the necessary erosion buffer to development on land at risk from long-term coastal erosion, (for example small-scale infill development including land division), such development should not occur unless:

a legally binding agreement is included on the relevant freehold certificate(s) of title(s) that protection measures will not be built and that any building will be transportable and will be removed when threatened by erosion or storm surge flooding; (See LDPs for City of Port Adelaide Enfield p.70, Port Pirie Regional Council p.78).

The South Australian government has set a state wide policy in respect to protecting future development from rising sea levels through the agency of the Coast Protection Board. This ensures development is suitably set back from the coast and is protected by its elevation from rising sea levels. As expected, these state wide provisions appear in the Port Pirie Development Plan (Department of Planning and Local Government, 2011 p.69). Port Pirie interviewees were of the opinion that further strengthening of these provisions are required via a change to the *Development Act 1993*. Port Adelaide Enfield also contains the standard state wide coast protection policies and it is expected that all coastal council development plans should do

likewise. The PAE plan contains frequent reference to climate change and explicitly notes that decisions made on the basis of the current plans need to take changing climatic conditions over the next 100 years into account (p.23, p.65, p.69).

Both plans contain only a single reference to storm surge which states, identically in each case, that development should:

'...be sited, designed and undertaken with appropriate precautions being taken against fire, flood, coastal flooding, storm surge, landslip, earthquake, toxic emissions or other hazards such as vermin' (See LDPs for City of Whyalla p.33, City of Playford, p.34).

Sea level rise is dealt with in both the Whyalla and Playford plans according to the standard state wide coast protection board specified policies. The policies relating to levee banks and restriction of development in flood plains cited above under the section on Flooding/Intense Rainfall, are also relevant in both cases.

SUMMARY

See Tables 2 and 3 for a summary of the analysis of land use planning policy and plans for response to climatic factors for Whyalla and Playford and for Port Pirie and Port Adelaide Enfield respectively. Planning in South Australia is driven by top-down policy frameworks set by state government. Recent initiatives and reforms, which have sought to increase the clarity and weight of state strategic policy and standardise the structure and wording of local development plan policy, means that there are few examples of significant differences in response to specific issues between development plans. The *Better Development Plans* project has had the effect of translating well constructed and innovative policy between plans. Whilst there appears to be evidence of autonomous adaptation to a dry climate in Whyalla, particularly in respect to planting and landscaping, this is not supported by any formal policy which differs from that in the target situation. In respect to flood risk, Port Pirie has developed a range of policy which is more extensive than that in the PAE target, but it lacks the researched data and mapping to support this policy. In contrast, PAE has developed the mapped data, but lags behind in policy development. Overall, it is difficult to discern any significant differences in land use policy between analogues and targets in South Australia.

Table 2 Analysis of integration of climate factors into land use planning policies, plans and processes for Whyalla and Playford

Whyalla - Playford					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
Whyalla LDP <ul style="list-style-type: none"> Shading and shade planting of public spaces 	Whyalla LDP <ul style="list-style-type: none"> Minimise consumption, maximise conservation and encourage water reuse. Water discharge rate should not exceed pre-development rate. -Wetlands development 	Whyalla LDP <ul style="list-style-type: none"> Mapped areas of bushfire risk, siting and design policies in bushfire risk areas 	Whyalla LDP <ul style="list-style-type: none"> Planting to counter effects of windblown dust 	Whyalla LDP Development should not take place in flood threatened areas unless 100 yr ARI can be satisfactorily dealt with through drainage and design.	Whyalla LDP Take appropriate precautions against fire, flood, coastal flooding , storm surge etc
Playford LDP <ul style="list-style-type: none"> Shading and shade planting of public spaces 	Playford LDP <ul style="list-style-type: none"> Water discharge rate should not exceed pre development rate. -Wetlands development 	Playford LDP <ul style="list-style-type: none"> Mapped areas of bushfire risk, siting and design policies in bushfire risk areas 		Playford LDP Development should not take place in flood threatened areas unless 100 yr ARI can be satisfactorily dealt with through drainage and design.	Playford LDP Take appropriate precautions against fire, flood, coastal flooding , storm surge etc.

Table 3 Analysis of integration of climate factors into land use planning policies, plans and processes for Port Pirie and Port Adelaide Enfield

Port Pirie – Port Adelaide Enfield					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/ intense rainfall	Coastal
Port Pirie LDP <ul style="list-style-type: none"> Shading and shade planting of public spaces 	Port Pirie LDP <ul style="list-style-type: none"> Stormwater capture and reuse 	Port Pirie LDP <ul style="list-style-type: none"> Bushfire Protection areas 	Port Pirie LDP <ul style="list-style-type: none"> Planting to counter effects of windblown dust 	Port Pirie LDP <ul style="list-style-type: none"> Development only on land protected from flooding by higher land, tidal levees and stormwater drainage Floor level specifications Low lying land not to be zoned for development Control of development adjacent to flood levees 	Port Pirie LDP <ul style="list-style-type: none"> Elevation and set back from coast as in state coastal planning policy
Port Adelaide Enfield LDP <ul style="list-style-type: none"> Shading and shade planting of public spaces 	Port Adelaide Enfield LDP <ul style="list-style-type: none"> Stormwater capture and reuse 			Port Adelaide Enfield Seawater Flooding Study (2005) <ul style="list-style-type: none"> Detailed mapping not yet translated into policy 	Port Adelaide Enfield LDP <ul style="list-style-type: none"> Elevation and set back from coast as in state coastal planning policy

2.2.2 Infrastructure

Infrastructure is very costly and, as revealed by interviews, often beyond the capacity of local governments to deliver. Furthermore, infrastructure is long life, often designed for a life of 50 to 100 years, with related design standards. Planning and infrastructure policies require regular review to check risk management criteria, such as the one in 100-year flood allowance, especially as the frequency of events is increasing. Because of its long life, infrastructure planning and design need to take into account long-term trends in climate, with planning for resilience. The Garnaut Review's report on the impact of climate change on infrastructure, focusing on buildings in coastal settlements, electricity and water and port infrastructure, emphasises that coastal infrastructure is especially vulnerable, with Queensland and Western Australia at highest risk. It should be noted that the impact of climate on infrastructure is often viewed in terms of maintenance, but seldom in terms of its strategic planning and location/relocation. Comparing what is being done now in more southern settlements (targets) with what is being done in more northern settlements (analogues) provides an indication of the gaps that may need addressing.

The Strategic Infrastructure Plan for South Australia (Department for Transport, Energy and Infrastructure, 2005a) is the primary infrastructure policy and plan in this state, and this is accompanied by a *Regional Overview* (Department for Transport, Energy and Infrastructure, 2005b). Both documents are in the process of being updated so they align with, and support, the SA Planning Strategy consisting of the *30-Year Plan for Greater Adelaide* (Department of Planning and Local Government, 2010) and the *Planning Strategy for Regional South Australia* (Department of Transport and Urban Planning, 2007) and its associated plans and master plans.

HEAT

The effect of heat on South Australian transport (rail) infrastructure was dramatically illustrated by the severe 2009 heatwave, when rail lines buckled and transport services disrupted. This issue is common to South Australia, Western Australia and Queensland, and has attracted the attention of the Australian Rail Track Corporation, the Cooperative Research Centre (CRC) for Rail Innovation and others, as discussed further in this chapter. Further study is also required to determine if there are regional differences.

The South Australian Local Government Association has noted that a trend is developing for rural road networks: the risk of damage to sealed roads from extreme weather events will necessitate changes to the average resealing period and see a need to consider more resilient materials in construction. With reduced capacity to undertake regular grading operations, unsealed roads have been identified as being more likely to present public safety issues as deterioration becomes more rapid. In some cases, councils may need to increase budgets to engage additional services, like grading contractors and water tankers or, alternatively, close these roads until conditions improve. Materials with greater resilience are being investigated (Local Government Association of South Australia and the LGA Mutual Liability Scheme, 2010).

The Port Pirie Regional Council (PPRC) is undertaking a review of its Road Management Plan and Roads Register and update in response to the rapidity of deterioration of sealed pavements by making adjustments to the average resealing period. It will conduct more frequent and rigorous treatments of sealed pavements to reduce the impact of oxidation. Furthermore, it will undertake a cost-benefit analysis for the integration of more resilient bitumen into road and tarmac construction and maintenance processes, including the use of sustainable products eg Ecopave. PPRC is undertaking a traffic analysis survey of infrequently used roads and considering plans for closures where necessary. PPRC is also investigating stabilisation techniques for unsealed roads, including additives to road aggregate and incorporate into design specifications (Port Pirie Regional Council, 2006). The extent to which the above initiatives are driven by climate factors, in addition to cost saving, is unclear. However, the impact of heat on

infrastructure, and the need for shade structures in playgrounds and similar facilities, were raised in an interview with the Port Pirie Regional Council (Interview, 7 December 2010).

PPRC is also developing a Shade Policy that considers natural and structured shade alternatives. It will undertake an audit of playgrounds, sporting facilities and the Port Pirie and Crystal Brook Swimming Pools to determine adequacy of current shade structures and identify shade deficiencies. It will develop an implementation plan for provision of shade at playgrounds, sporting and swimming facilities based on an assessment of vulnerable users, visitation and claims history. It is also developing strategies for monitoring turf condition and the closure of sporting fields that become 'unfit' for purpose (Port Pirie Regional Council, 2009).

Turning to City of Port Adelaide Enfield and City of Playford, whilst there was some reference to shade related policies and plans, these were not to the same extent as their northern analogues. For example, the Asset Management Plan for Parks and Gardens in the City of Playford contains provisions to develop and maintain recreation and sporting facilities and grounds, and to 'create, improve and maintain parks and open space with facilities such as shade, seating, BBQ's' (City of Playford, 2010a).

DROUGHT

The LGA recognises that impacts of extreme heat, less average rainfall and sea level rise all hasten the rate of asset deterioration, change maintenance regimes, prompt relocation and demand the construction of new, more resilient infrastructure. Similarly, the LGA notes that community wastewater management systems offer an opportunity for further analysis to expand South Australia's capabilities for water reuse (Local Government Association of South Australia and the LGA Mutual Liability Scheme, 2010). Certainly, the topic of water shortages and increased salinity in the northern analogues, and the impact on industry, agriculture and townships, loomed large in interviews with the Eyre Peninsula NRM Board (23 September 2010), the City of Whyalla (29 November 2010) and the Port Pirie Regional Council (7 December 2010).

SA Water is responsible for water and wastewater systems at Port Pirie, Port Augusta and Whyalla. The Beetaloo and Baroota reservoirs are located to the east of Port Pirie just outside the region. They have a total capacity of 9,000 ML, are currently isolated from the SA Water system and retained for emergency use only. There is some use of Baroota water for irrigation with limited potential for expansion (Department for Transport, Energy and Infrastructure, 2005).

The National Water Security Plan for Cities and Towns program is a key component of the Federal Government's comprehensive, long-term 'Water for the Future' initiative (Commonwealth of Australia, 2011). Under this program, the Port Pirie community water reuse project has funding of \$2.5 m. It will cover policy and technical specifications for water sensitive irrigation design, including water reuse schemes and sub-surface irrigation. PPRC also noted (Interview, 7 December 2010) various water harvesting opportunities within the council, including a \$5m re-use agreement with Nyrstar. Whyalla is also evaluating options, including desalination, to augment water supplies to support industrial and community growth (Department for Transport, Energy and Infrastructure, 2005b).

PPRC also mentioned (Interview, 7 December, 2010) community expectations that parks/sporting fields must be 'green', adding that 'Council is now expected to provide green space, since houses are smaller and have less land.' Sport forms part of the country community social fabric, and PPRC has a number of ovals. The council is also promoting 'sport event tourism' in the town. But 'dry areas will not look good'.

At the same time, drought implies less water to irrigate such reserves and thus they tend to become unattractive dust bowls. In addition, the requirement for more water to irrigate parks and public spaces imposes additional cost on the local council, which is seeking to reduce, consolidate and optimise the use of its public space assets. Sports ovals are a key case in point,

since in many regional communities they are a social focal point that could lose their appeal as they lose their greenness. Thus, the combination of heat and drought may have impacts on community cohesion and opportunity for social exchange (Interview, Port Pirie Regional Council, 7 December 2010).

The PPRC is exploring integrated water capture, storage and reuse projects in the region (see Port Pirie Regional Council 2010b). In conjunction with Nyrstar, it has recently won a grant for water reuse in Port Pirie, which would see Nyrstar treating water used through the plant for both Nyrstar reuse and a component made available to council for use on public spaces. Detailed planning for the project is budgeted to commence in 2010/11 (Port Pirie Regional Council, 2010c).

Tonkin Consulting (2008) has conducted an investigation in Crystal Brook on potential reuse of the treated water from the Community Wastewater Management Scheme (CWMS) as a Stage 1 project and collection and reuse of stormwater as a Stage 2 project. Council recently received Federal grant funding for this project.

Similarly, Whyalla needs to be seen as green (literally) and having a good quality of life, so it is seeking to utilise more urban stormwater and recycle water. Wetlands and water recycling are well developed in Whyalla because of necessity, and aquifer recharge utilised. The golf course is irrigated with recycled water (Interview, City of Whyalla, 29 November 2010). According to its Annual Report, the council continues to work with SA Water to expand effluent reuse initiatives. It is in discussion with SA Water and OneSteel, UniSA and BHP Billiton regarding water and treated effluent use. It signed a contract with SA Water for 350ml treated effluent, and is getting contracts signed with other end users (City of Whyalla, 2010a p.14).

Whyalla has begun flood mitigation and storage capture systems, although not successful in gaining federal funding, and continued mitigation measures with swales and stormwater retention dam at industrial estate. The council is considering median strips as water retention systems. It uses the ASR dam for street watering, and emptied redundant SA Water storage tanks for street tree watering and road construction on unsealed roads. It also used ASR water for crushing contract for industrial estate road construction. Subsurface irrigation systems are installed in parks and reserves, with computer controlled watering systems. It continues to examine appropriateness of plant species and to develop its landscape plan. It has also started use of treated effluent. In addition to these measures, reduced flows in the River Murray and the substantial demands of industry in the region have led to having a desalination plant now being proposed (City of Whyalla, 2010b).

Turning to Port Adelaide Enfield and Playford, whilst there is also considerable activity to address drought, there appears to be somewhat less concern regarding the dryness of sporting fields.

Waterproofing Northern Adelaide (WNA) was a joint project to improve urban water management in Adelaide's northern region. The cities of Playford, Salisbury and Tea Tree Gully worked together aided by a \$41.8 million grant from the Australian Government's Water Smart Australia program as well as state government, the Natural Resource Management board and private partners. Waterproofing Northern Adelaide will help to provide up to 80 per cent of irrigation water needs for irrigation. Key projects include developing major wetland sites and associated aquifer storage and recovery facilities at Munno Para West, Andrews Farm, and Adams Creek, along with a network of reticulation mains designed to deliver recycled storm water to council irrigation sites (City of Playford, 2011).

Within Port Adelaide Enfield, major Aquifer Storage Recovery (ASR) schemes have been implemented at Regent Gardens and Northgate. Regent Gardens is a residential development located 8 km northeast of the Adelaide CBD. Northgate is a major greenfield residential development that includes a five-lake stormwater retention and ASR scheme which has attracted international recognition. A new ASR scheme is also being investigated for development within the Barker Inlet Wetlands, in conjunction with SA Water (City of Port Adelaide Enfield, 2011).

BUSHFIRE THREAT

From an infrastructure perspective, there are no discernible differences in approaches to bushfire management between the analogue and target settlements.

Within the Port Pirie area, Origin Energy carries out clearance of overhead hazards throughout the district, maintains hazard free sub-stations and continually reassesses insulator design to prevent clashing of overhead lines. In recent years, it has adopted a policy of turning power off to areas in the district during extreme fire danger periods, rendering electrically driven fire pumps inoperable.

Within the Fire Danger Season, the Department for Environment and Natural Resources (DENR) undertakes slashing, mowing, grazing and fire track maintenance within its areas in accordance with their Fire Prevention Plan and fuel reduction policy. Transport SA has a roadside spraying, slashing and grading program to protect signposts, guideposts and roadside reserves and also to reduce hazard to depots.

The Playford District Bushfire Prevention Plan (City of Playford 2010b) has identified infrastructure at risk in each area of the council. The council engages with the SA Country Fire Service and Planning SA to ensure bushfire management planning policies meet changing bushfire conditions. A spatial analysis of council owned environmental buffers has been undertaken, which identified potential areas of loss and capacity for mitigation. The council seeks to demonstrate leadership by the use of best practice in the management of fuel loads on council land (City of Playford, 2010b)

HIGH VELOCITY WIND

Changing wind patterns have been a concern in Port Pirie in relation to increases in dust and hence blood lead levels, due to the Smelter. Dr Ted Maynard said that while there are other factors involved, 'the winds are probably the central issue' (ABC, 2004). In an attempt to stabilise the environment, the Environmental Health Centre and Port Pirie Council planted 100,000 trees around the town as part of a greening operation to change wind patterns and reduce dust (Sydney Morning Herald, 16 Jan 1988). Aside from the dust and lead issue, there was no evidence of high winds influencing policy. However, there is recognition of the positive effect of wind with a wind-powered desalination plant being mooted for Port Pirie. According to green energy and water company Windesal, this could solve the power and water needs of Port Pirie and at the same time provide a jobs boom (Hughes PR, 2010).

The impact of wind and storms is acknowledged by the City of Port Adelaide Enfield (in its Emergency Response Plan (City of Port Adelaide Enfield, 2010a). The council is seeking funding to further undertake studies on climatic adaptation changes, including the impact of a major storm, such as a tornado, in the council area. These studies would consider potential community shelter accommodation, such as the Civic Centre and potential venue support for the State Emergency Service (SES) Command Centre.

FLOODING/INTENSE RAINFALL

Stormwater infrastructure is a concern for most councils, because it is generally designed to cope with 1 in 5 year events. More intense storms than these cause the system to surcharge and flooding becomes likely. With climate change, the increased frequency and intensity of rainfall is making 1 in 10 year events more frequent, so testing the system capacity. Combined with rising sea level, land subsidence and 'backflow', this changing situation means that urban storm water systems are becoming less and less efficient and more frequently unable to cope.

Both the northern analogues and the southern targets are experiencing more intense rainfall events accompanied by flooding, with this being a major concern for both City of Port Adelaide Enfield (Interview, 25 October 2010) and Port Pirie Regional Council (Interview, 7 December 2010). Both analogues and targets provided evidence of efforts being made to address these risks, with the targets making more progress through greater resources.

Port Pirie suffered severe flooding and extensive rainfall when the Broughton River flooded in March 2006, a 1 in 50 year event which caused extensive damage. Furthermore, in January 2007, storm waters of up to 125 millimetres flooded the Port Pirie township, Napperby township and the surrounding area. The damage to council infrastructure was in excess of \$2 million (Burfitt, 2007; ABC, 2007). The flood also affected a housing area that the then Chief Executive Officer and planners had warned was vulnerable but was built upon despite the contrary advice. Councillors refused to accept the danger (Interview, City of Whyalla, 29 November 2010).

Within its scarce resources, Port Pirie Regional Council (2011) is now seeking to address these risks. It has commissioned a comprehensive study of its storm water infrastructure in both Port Pirie and Crystal Brook with a view to determining the adequacy of these assets and to prepare a plan for their upgrade to meet Australian Standards for a 1 in 100 year rainfall event. It is updating council's *Asset Management Plan (Stormwater Management and Drainage Systems) and Records Management System* with an effective inspection regime and risk management for stormwater and road assets to reflect increased frequency of flash flooding. It is recognised that the risk of damage to sealed roads from extreme weather events will necessitate changes to the average resealing period and see a need to consider more resilient construction materials. The council is also undertaking hydrological modelling of catchments, with the current level of development and ultimate level of development being summarised each catchment. For example, for the southern catchment, the developments approved to date rely on retention storage in the allocated reserve for the management of stormwater generated from the sites. It is reviewing effectiveness of tidal wall/levee banks and implementing a management plan to address any gaps in this infrastructure and future increases due to climate change predictions. Moreover, the council is developing infrastructure standards and performance measures; a flood disaster management plan; and council's long-term financial plan incorporates a contingency fund for asset replacement costs as a result of flooding.

However, despite these efforts, the council lacks sufficient resources to adequately address this serious problem, either through policy revision or public works (Interview, Port Pirie Regional Council, 7 December 2010). By contrast, City of Port Adelaide Enfield (PAE) in metropolitan Adelaide had commissioned a detailed study of flood risk in its area. This illustrates a further key factor which is crucial in the development and implementation of adaptation strategies. PAE has an officer employed full time to address climate change issues. It is also located at the end of the chain of metropolitan councils in the sense that storm water from upstream councils will flow into PAE's stormwater system making it extremely vulnerable to extreme rainfall. PAE commissioned the study on the basis of the twin threat from the above and from rising sea levels (Interview, City of Port Adelaide Enfield, 25 October 2010). Here, we have an example of the target being well ahead of the analogue in its response to existing and past climate, partly because of the threat to critical infrastructure, but mostly because of better resourcing.

Being a city with a population of 21,000, with infrastructure designed for three times that number, Whyalla is in the fortunate position of having oversized systems which can cope with extreme events. However, the city has 60 per cent reliance on above ground storm water drainage systems, resulting in significant flooding occurring during extreme rainfall. The nearby airport is subject to significant run off from the area behind, and the airport runway was flooded in 2007. The storm drains are increasingly seen as inappropriate in design and capacity. Modifying existing systems with upstream water capture and retention, and the development of wetlands into which storm water can be diverted in periods of extreme rainfall, may prove to be more cost effective and sustainable solution, which also bring ecological benefits (Interview, City of Whyalla, 29 November 2010). Whyalla has already invested in such solutions as have a number of councils in Metropolitan Adelaide.

In partnership with the City of Playford, the NRM Board developed stormwater master plans for urban areas of the Playford region. It is facilitating an increase in awareness of flood risk and implementing flood mitigations works (NRM). The Virginia Flood Safety Program is of particular importance, as a Virginia flood occurs every 10 years on average, and the Virginia Playground and Recreational Space Project responds to flooding risks (Adelaide and Mt Lofty Ranges Natural Resource Management Board, 2006).

COASTAL

As noted above, the threat of both sea level rise and coastal storm surges has been recognised by both Port Pirie and Port Adelaide.

The Port Pirie Regional Council's Development Plan, under the *Development Act 1993*, has specified principles and objectives relating to sea level rise to achieve public safety and reduced property damage, and it provides a good mechanism to inform decision making regarding development in the coastal zone (Department of Planning and Local Government, 2011a). Port Adelaide has an Emergency Response Plan for major storms and severe weather events which oversees requests for road closures, sandbagging and also staff and machinery support (City of Port Adelaide Enfield, 2010).

The Development Plan for Port Pirie (Department of Planning and Local Government, 2011) requires 'hazard risk minimisation' (p.76). Under s349, development should not compromise the structural integrity of any sea wall or levee bank adjacent to the coast or a river foreshore, or compromise its capacity to protect against coastal flooding and erosion. Under s350, development, including associated earthworks, should not (a) impede the effectiveness of the levee on the subject land or other surrounding land; (b) increase the potential hazard risk to public safety of persons during a flood event; (c) aggravate the potential for erosion or siltation or lead to the destruction of vegetation during a flood; (d) cause any adverse effect on the levee function; (e) increase the risk of flooding of other land. The Plan includes the need to develop a robust asset plan and long term financial plan which includes alternatives for external funding to meet infrastructure costs from flood mitigation works, maintenance and damage; consider alternatives for asset rationalisation and/or rate review to meet infrastructure costs from flood mitigation works, maintenance and damage; develop and disseminate a traffic management plan that considers an assessment of the road network that is at risk from coastal inundation; incorporate reengineering and/or relocation strategies for roads and other infrastructure vulnerable to coastal inundation into the Asset Management Plan.

According to its *Drainage Management Plan Review 2009*, the council is seeking to review the effectiveness of tidal wall/levee banks and implementing a management plan to address any gaps in this infrastructure and future increases due to climate change predictions. The current gravity outfall of stormwater management system will be inoperable during coastal inundation, storm surge and/or high tide. It plans to undertake reanalysis of the Port Pirie levee system and ensure engineering integrity of infrastructure to meet predictions for sea level rise and impacts from storm surge and extreme high tides (Port Pirie Regional Council, 2010d).

Adjacent Whyalla, there has been significant sand loss, with new sand banks appearing out at sea. The Coast Protection Board estimates 1 metre of sand has been lost as a result of recent storm events (Interview, City of Whyalla, 29 November 2010). Now the retention bank built in 1950s is being undermined as a result. However, it is uncertain whether these events are related to climate factors or the construction of the marina within last 15 years.

Turning to Port Adelaide, the *Port Adelaide Seawater and Stormwater Flood Study* (Tonkin Consulting, 2005) recognises that critical infrastructure is at risk of flooding due to sea level rise, storm surges and inland drainage. This includes three power stations that supply the bulk of South Australia's electricity; the port site (Birkenhead), where all of metropolitan Adelaide's fuel supplies are received and distributed; major industrial sites (Adelaide Brighton Cement, Penrice

etc); the new naval precinct (Techport) where the Commonwealth's warfare destroyer project is occurring; and an international port (Outer Harbor) that serves both Adelaide's domestic markets, but also commodities import and export, including the northern SA mines expansion.

An Emergency Response Plan concerning breach of the seawall and/or levee bank has been developed. The sea wall stops North Arm Creek high tides from accessing adjoining suburbs of Dry Creek, Wingfield and Gillman (City of Port Adelaide Enfield, 2010).

The City of Playford has established policies and plans to mitigate the risk of coastal events. It is reviewing the City of Playford Drainage Management Study to ensure that spatial modelling has taken into consideration sea level rise and storm surge calculations and initiates changes to flood plain mapping where necessary. It is reviewing and updating its Drainage Management Policy to incorporate sea level rise and storm surge as key impacts on stormwater and drainage. And it is seeking to ensure that its asset management plan has the capacity to monitor the condition of coastal infrastructure.

SUMMARY

See Tables 4 and 5 for a summary of the infrastructure policy analysis and plans for response to climatic factors for Whyalla and Playford and for Port Pirie and Port Adelaide Enfield respectively. Considering the analogue and target locations in South Australia, the most discernible differences in policies, plans and practices were related to dealing with drought. Port Pirie and Whyalla appeared to be in advance of their southern targets in their infrastructure responses and approaches to sporting grounds and planting. Whilst both analogues and targets were undertaking water reuse and treated effluent projects, aquifer storage and recharge, water retention systems and the like, there appeared to be more urgency in the case of the northern analogues. Water shortages were a major topic raised in interviews with the Eyre Peninsula NRM Board and with the regional cities of Port Pirie and Whyalla.

On the other hand, northern analogues could learn from their southern targets on how to deal with flooding and coastal issues, with an expressed desire for both knowledge and financial resources.

Table 4 Analysis of integration of climate factors into infrastructure policies, plans and processes – Whyalla - Playford

Whyalla - Playford					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Whyalla No evidence</p>	<p>Whyalla Whyalla Council Annual Report</p> <ul style="list-style-type: none"> Wetlands and water re-use and recycling well developed, also aquifer recharge for street watering Median strips as water retention systems Golf course irrigated by recycled water Treated effluent initiatives with One Steel, BHP Billiton and UniSA in conjunction with SA Water 	<p>Interview, Whyalla City Council 29 November 2010</p> <ul style="list-style-type: none"> Not seen as a big threat in Whyalla 	<p>Whyalla No evidence</p>	<p>Whyalla</p> <ul style="list-style-type: none"> Has begun flood mitigation and storage capture systems 60% reliance on above ground storm water drainage systems. Airport at risk Ocean Eyre development built in flood plan 	<p>Whyalla</p> <ul style="list-style-type: none"> Sand loss – but may be due to man-made structures e.g. the marina
<p>Playford City of Playford Asset Management Plan for Parks & Gardens (2010)</p> <ul style="list-style-type: none"> Some minor reference to shade 	<p>Playford Waterproofing Northern Adelaide Project</p> <ul style="list-style-type: none"> Will provide up to 80% of irrigation water 	<p>Playford District Fire Prevention Plan (2010)</p> <ul style="list-style-type: none"> Identified infrastructure at risk 	<p>Playford No evidence</p>	<p>Playford City of Playford Drainage Management Policy</p>	<p>Playford City of Playford Drainage Management Policy</p> <ul style="list-style-type: none"> Mitigate risk of coastal events

Table 5 Analysis of integration of climate factors into infrastructure policies, plans and processes – Port Pirie and Port Adelaide Enfield

Port Pirie – Port Adelaide Enfield					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Port Pirie Regional Council Road Management Plan (2006),</p> <p>PPRC developing shade policy.</p> <p>Interview 7 Dec 2010</p> <ul style="list-style-type: none"> • Need for shade structures raised in 	<p>Port Pirie Regional Council Road Management Plan (2006)</p> <p>Crystal Brook Community Wastewater Management Scheme (2008)</p> <ul style="list-style-type: none"> • Pt Pirie community water re-use project • Water treatment and harvesting agreement with Nyrstar – use water on public spaces • Concern about dryness of sporting fields 	<p>Port Pirie</p> <ul style="list-style-type: none"> • Origin Energy turns off power during extreme fire danger, and programs to prevent clashing of wires 	<p>Port Pirie</p> <ul style="list-style-type: none"> • Greening program, planted 100 000 trees around town to reduce wind borne dust and hence blood lead levels due to Smelter • Wind powered desalination proposed (2010) 	<p>Port Pirie</p> <ul style="list-style-type: none"> • Pt Pirie suffered severe flooding 2006, 2007 • Burfitt, Ian (2007), Port Pirie Regional Council: Climate Change Issues, Presentation to Planning Institute of Australia, SA Division, 9 March • PPRC study of stormwater infrastructure and plan for 1 in 100 year event. • Flood disaster Management Plan • PPRC lacks resources and knowledge to address risk (Interview 7 Dec 2010) 	<p>Port Pirie Regional Council Development Plan (2011)</p> <ul style="list-style-type: none"> • Principles, objectives re: sea level rise • Hazard minimisation s349, 350 • council reviewing levee system/tidal wall
<p>Port Adelaide Enfield No evidence</p>	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> • ASR schemes at Regent Gardens, Northgate and Barker Inlet Wetlands. 	<p>Port Adelaide Enfield No evidence</p>	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> • Seeking funding for study re impact of storms e.g. tornado on council area • Emergency Response Plan 	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> • Port Adelaide Seawater and Stormwater Flood Study. 	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> • Port Adelaide Seawater and Stormwater Flood Study

2.2.3 Housing/Building

Building standards in South Australia are part of the development assessment framework provided by the *Development Act 1993* and *Development Regulations 2008*. The Department of Planning and Local Government produces the South Australian Building Code which specifies the deemed-to-satisfy requirements of the BCA.

HEAT

A feature of the analogue/target pairings for South Australia, which was different from those in Western Australia and Queensland, is that the SA pairings are in different climate zones. There are eight climate zones defined in the BCA ranging from zone 1 in the north of Australia, which is typified by high humidity summers and warm winters, through to zone 8, which includes the cold winter alpine areas. The BCA places Port Pirie and Whyalla in zone 4 whereas Port Adelaide Enfield and Playford are in zone 5. The fact that the targets and analogues are in different climate zones informs the target communities that, in general, higher building envelope performance will be necessary based on the experience of creating acceptable conditions in buildings in the analogue communities. This will require modification of the specifications of new houses with target designs following the analogue example. There are differences for energy efficiency (relating to heating and cooling energy loads) in the deemed-to-satisfy requirements of the BCA for zone 4 and zone 5 buildings which include:

Housing – BCA 2011 Volume 2, Section 3, Acceptable Construction, Part 3.12 Energy Efficiency. The deemed-to-satisfy provisions show some differences in the areas of:

- the shading and insulation of dense external walls
- external glazing specifications
- the insulation of services i.e. pipework and ductwork
- minimum total R values for suspended floors
- provision for air movement
- commercial buildings – BCA 2011 Volume 1, Section J, Energy Efficiency. The deemed-to-satisfy provisions show some differences in the areas of:
 - minimum total R values for envelope walls (other than external walls)
 - total R values for suspended floors
 - external glazing specifications (energy index)

See Box 1 for a discussion about some of the differences in how the BCA is applied in each area for housing.

It is also possible to gain compliance for energy efficiency using the alternative solutions route rather than the deemed-to-satisfy provisions. For houses, this method uses Nationwide House Energy Rating Scheme (NatHERS) software for rating house designs in conjunction with local climate data known as Typical Meteorological Year (TMY) data. There are currently 69 climate TMY datasets (increasing to 80) for the whole of Australia and six within South Australia. For the Port Pirie and Whyalla analogues, the relevant climate is TMY dataset 45 and for the Port Adelaide Enfield and Playford targets, it is TMY dataset 16. Buildings other than housing e.g. hotels, offices, shops, medical facilities and education buildings as described in Volume 1 of the BCA, can also comply with the energy efficiency requirements via the alternative solution route using approved building energy analysis software with local climate data.

Hence, consideration of the current requirements of the BCA show differences between analogues and targets as far as energy efficiency is concerned. These differences provide an indication of measures that may be adopted by targets for modifying the thermal performance of buildings.

Box 1 BCA Climate Zones

Box 1 BCA climate zones

The use of eight climate zones for Australia in the regulation of the energy efficiency performance of buildings is an example of current policy responding to climate factors. This manifests itself in different specifications for the building envelopes i.e. roofs, walls, windows and floors for the various climate zones. A suitable case study is that of a residential building located in different climate zones, and this is conveniently provided by the South Australian analogue and target pairs since the analogues are in climate zone 4 and the targets are in climate zone 5. A study of the deemed-to-satisfy provisions of Volume 2 (BCA) of the National Construction Code, Section 3 Acceptable Construction, Part 3.12 Energy Efficiency reveals differences in certain building requirements. These are also summarised in the South Australian Housing Code Appendix H – Energy Efficiency (SA Govt. 2011) and the main differences between zone 4 and 5 are as follows:

- With dense external walls, requirements differ with respect to shading of the wall, external glazing specifications (both solar heat gain factors and U values) and R value of wall insulation.
- With suspended floors, the minimum total R values are significantly higher for zone 4.
- External glazing requirements differ and are dependent on orientation, solar heat gain factors and U values. Essentially, the area of glass is limited depending on the level of shading provided and orientation.
- For heating and cooling ductwork insulation, the minimum R values are different between zones 4 and 5.
- There are modest differences in air movement provisions for habitable rooms.

Hence, in this case, there are currently differences in building specifications between the analogue and target which could be further developed for future climate scenarios.



National Construction Codes specify requirements for residential dwellings . Photograph: S.Pullen

Beyond the scope of the BCA and at a local level, is the action of Port Pirie Council to develop a plan for enhancing the cooling efficiency of council buildings with passive mechanisms including exterior paint, window treatments (double glazing, tinting, shutters, blinds) and insulation. This initiative could be adopted by target councils.

DROUGHT

Port Pirie Regional Council is proactive in this area and, in conjunction with SA Water and around 40 other councils in the state, is participating in a free showerhead swap campaign as part of an endeavour to reduce household water consumption. Old shower heads will be able to be swapped free of charge for a new more water efficient device. In addition, the council is supporting the WaterWise Communities Kit and is encouraging residents and businesses to collect and reuse rain water. A recent expectation of the council by residents is the provision of green space, since houses are now built on smaller areas of land. Many Whyalla citizens seem to have adapted to high heat and low water availability by turning gardens in to native planted areas and removing grassed areas. An addition to the BCA for South Australia since 1st January 2006, has been the requirement for all new houses to have a plumbed-in rainwater tank. Of course this applies equally to the analogues and targets in the state.

BUSHFIRE THREAT

The BCA references *Australian Standard AS 3959. 2009 – Construction of buildings in bushfire-prone areas*. Planning SA has mapped Bushfire Protection Areas for 39 affected councils located throughout SA, including Eyre Peninsula, Yorke Peninsula, Kangaroo Island, the South-East, the

Riverland, Murray Bridge, mid-North (including Port Pirie), Mt Lofty Ranges and parts of the Metropolitan Adelaide region. Whyalla is not included in this mapping. Each of these areas has been thoroughly assessed and categorised into one of three bushfire risk levels – high bushfire risk, medium bushfire risk or general bushfire risk with other non-risk areas excluded. Requirements for new construction may include features such as having dedicated water supplies for fire fighting; buffer zones between homes and flammable or combustible vegetation; appropriate access roads; and building features which increase bushfire protection. It is possible that risk levels will increase with climate change and current boundaries will change.

HIGH VELOCITY WIND

Various natural hazard occurrences, including wind, are referred to in Section B of Volume 1 of the BCA. In addition, dwellings and most smaller buildings must be designed and constructed to cope with wind gusts with an annual probability of exceedance of 1:500, i.e. a wind event where the probability of occurring is once every 500 years. The specified document in the BCA is AS/NZS 1170.2:2011 Structural design actions Part 2: Wind actions. This provides a map dividing Australia into various wind regions including cyclonic and non-cyclonic areas. Both the analogue and target for the South Australia pairings are within the same Region A1 described in AS/NZS 1170.2:2011.

FLOODING/INTENSE RAINFALL

There are no specific requirements for avoiding flooding in the BCA at present. Generally, areas subject to flooding have their own regulations and directives for building in such locations and these are applied at the local authority level based on historic data. The ABCB has included a project on the 2010-11 work program for the development of a technical standard for housing and other low rise residential buildings in flood prone areas. Possible amendments to the BCA might include flood resistant construction materials, elevated floor heights and more robust footings and foundations.

The BCA for non-residential buildings – Volume 1 Section F Health and Amenity section –covers stormwater drainage and roof coverings and refers to the relevant Australian Standards. Five minute rainfall intensities at 20 year and 100 year recurrence intervals for different locations are provided in Volume 2 Section 3.5 Roof and Wall Cladding. Adelaide and Port Pirie are listed but these have similar intensities for 20 years and are marginally higher for Port Pirie (201 mm/hr compared with 186 mm/hr) at 100years.

COASTAL

There are no specific requirements for avoiding flooding in the BCA.

The Port Pirie (RC) Development Plan, (2011) under the *Development Act 1993* has specified principles and objectives relating to sea level rise to achieve public safety and reduced property damage and provides a good mechanism to inform decision making regarding development in the coastal zone. Port Adelaide has an Emergency Response Plan for major storms and severe weather events which oversees requests for road closures, sandbagging and also staff and machinery support.

SUMMARY

See Tables 6 and 7 for a summary of the housing and building policy analysis and plans for response to climatic factors for Whyalla and Playford, and for Port Pirie and Port Adelaide Enfield

respectively. In the area of Housing and Building, the most obvious difference in policies and guidelines between target and analogue locations in response to current climates is due to the different climate zones as defined by the National Construction Code. Within this code (more commonly known as the BCA), the area of building performance that is different for the South Australian pairings is that of energy efficiency. This provides a tangible learning for targets from the experience of the analogues. There have been other initiatives either taken or planned at a local level by the analogues, such as modifying garden plantings to suit lower rainfall and improving the energy efficiency of council facilities.

Table 6 Analysis of integration of climate factors into housing and building policies, plans and processes for Whyalla and Playford

Whyalla - Playford					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Whyalla BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> • The deemed-to-satisfy building envelope specifications are for climate zone 4. • The alternative solutions route via thermal simulation software uses local meteorological datasets. 	<p>Whyalla</p> <ul style="list-style-type: none"> • BCA requirement for rainwater tanks in new houses • Adaptation to drought tolerant gardens 	<p>Whyalla</p> <ul style="list-style-type: none"> • Mapped areas of bushfire risk; BCA reference to construction of buildings in bushfire prone areas 	<p>Whyalla No evidence</p>	<p>Whyalla No evidence</p>	<p>Whyalla No evidence</p>
<p>Playford BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> • The deemed-to-satisfy building envelope specifications are for climate zone 5. • The alternative solutions route via thermal simulation software uses local meteorological datasets. 	<p>Playford</p> <ul style="list-style-type: none"> • BCA requirement for rainwater tanks in new houses 	<p>Playford</p> <ul style="list-style-type: none"> • Mapped areas of bushfire risk; BCA reference to construction of buildings in bushfire prone areas 	<p>Playford No evidence</p>	<p>Playford No evidence</p>	<p>Playford No evidence</p>

Table 7 Analysis of integration of climate factors into housing and building policies, plans and processes for Port Pirie and Port Adelaide Enfield

Port Pirie – Port Adelaide Enfield					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense Port rainfall	Coastal
<p>Port Pirie BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> The deemed-to-satisfy building envelope specifications are for climate zone 4. The alternative solutions route via thermal simulation software uses local meteorological datasets. council have plans for more passive cooling efficiency in their buildings. 	<p>Port Pirie</p> <ul style="list-style-type: none"> council participates in showerhead swap campaign. BCA requirement for rainwater tanks in new houses council supports Waterwise Communities Kit. 	<p>Port Pirie</p> <ul style="list-style-type: none"> Mapped areas of bushfire risk. BCA reference to construction of buildings in bushfire prone areas. 	<p>Port Pirie No evidence</p>	<p>Port Pirie No evidence</p>	<p>Port Pirie No evidence</p>
<p>Port Adelaide Enfield BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> The deemed-to-satisfy building envelope specifications are for climate zone 5. The alternative solutions route via thermal simulation software uses local meteorological datasets. 	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> BCA requirement for rainwater tanks in new houses 	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> Mapped areas of bushfire risk. BCA reference to construction of buildings in bushfire prone areas. 	<p>Port Adelaide Enfield No evidence</p>	<p>Port Adelaide Enfield No evidence</p>	<p>Port Adelaide Enfield No evidence</p>

2.2.4 Health services

In South Australia (SA) the *Health Care Act 2008* defines a health service as a service associated with: the promotion of health and wellbeing; the prevention of disease, illness or injury; intervention to address or manage disease, illness or injury; the management or treatment of disease, illness or injury; rehabilitation or ongoing care for persons who have suffered a disease, illness or injury; a paramedical or ambulance service; a residential aged care service; a research, pathology or diagnostic service associated with veterinary science; or a service brought within the ambit of this definition by the regulations, such as the provision of linen and laundry services to hospitals or other health care providers. Health services coordinated by the Department of Health (SA) are defined in terms of either the community being serviced (e.g. Aboriginal health) the service being provided (e.g. ambulance and emergency; dental service); or the state name for the program (e.g. GP Plus Health Care services). At the state level, the SA Health Care Plan addresses the upgrade of hospital facilities to meet health challenges such as an ageing population, increasing incidence of chronic diseases, international workforce shortages and ageing infrastructure. The *GP Plus Health Improvement Plan* (Department of Health (SA), 2008a) identified that a Health in All Policies Approach would provide a collaborative methodology and system for identifying and working on health related issues across government, with local government and communities. According to Department of Health (SA), in country areas, hospitals and health services form a network designed to provide those living in regional SA with the 'best solution to their health care needs'.

Health Advisory Councils are based geographically to 'ensure a continuing strong link between communities and their health services'. The Country Health SA Board Health Advisory Council works with Country Health SA to plan health services for the people of rural and remote SA. A program 'careconnect.sa' was being developed, linking up country hospitals, mental health and community services to provide care as close to home as possible. In metropolitan areas, regional public hospitals are supported by private hospitals, aged care facilities and medical centres to provide a network of health services. Emergency management is a responsibility of the Emergency Management Council (EMC), a committee of Cabinet chaired by the Premier. The SA State Emergency Services (SASES) is the control agency in the event of extreme weather and provides hazard leadership. Emergency management responsibilities are coordinated by SASES at a regional or multi-council level with councils being responsible for preparing an emergency response plan.

In the analogue area, the Whyalla Hospital and Health Service is part of the Whyalla Eastern Eyre and Far North Health Services. Whyalla provides a wide range of services utilising local general practitioners, resident specialists, visiting specialists and telemedicine for people in the surrounding areas. Whyalla Hospital and Health Service provides a 24-hour accident and emergency service and has a team of medical practitioners that can be called as required. The standard advice given is: 'In a medical emergency, it is important that you do not 'self present' to hospital'.. SA Ambulance Service staff provides advanced first-aid advice over the phone while an ambulance is on its way.

Port Pirie Hospital and Regional Health Service in the Yorke and Mid North Region has 95 beds available for people with an acute medical condition, adults and children, surgical, obstetric, palliative care and care for people over 75 years of age. The hospital offers a high dependency unit and private rooms. Accident and emergency and the reception area are open 24-hours a day. The hospital is complemented by a network of health providers delivering an extensive range of specialist, community and allied health services, including dentists, orthodontists, chiropractors and physiotherapists. The South Australian Government has committed \$12.5 million to develop an integrated primary health care GP Plus Centre at Port Pirie, estimated to be completed in 2013 (Department of Planning and Local Government, 2009, p.5). *The Draft 10 Year Local Health Service Plan for Mid North* (Department of Health (SA), 2010a) outlines an aim for Country General Hospitals (such as Whyalla and Port Pirie) to be developed to manage the majority of health care needs so that only those patients requiring highly specialised or complex care will need to travel to Adelaide for these services. It is anticipated that Country General

Hospitals will have an increased capacity, a high complexity of services and a range of enhanced and new health services to provide care as close to home as possible (p. 9).

In the target communities in metropolitan Adelaide, the Central Northern Adelaide Health Service (CNAHS) is the largest of South Australia's health regions established in 2004. The CNAHS employs more than 16,000 staff across some 200 separate hospitals, health units and services. The Lyell McEwin Hospital (LMH) in the City of Playford, is a 257-bed acute care teaching hospital that provides a full range of medical, surgical, diagnostic, emergency and support services to a population of more than 300,000 people living primarily in Adelaide's northern suburbs. The LMH Emergency Department is open 24-hours a day, providing health care to more than 51,000 people each year. There are no major public hospitals in the City of Port Adelaide Enfield area, the closest being the Queen Elizabeth Hospital in the adjoining City of Charles Sturt. In the Adelaide metropolitan area, councils have a responsibility for developing an emergency response plan which may be coordinated at a multi-council level as evidenced by the Playford - Gawler Emergency Management Plan which identifies fire, flood, extreme weather, shortages of fuel, gas and electricity, animal and plant diseases, human epidemic/pandemic and contamination of food and drinking water as risks.

The following sections address the main aspects of how health services relate to the specific climate factors in each of the SA analogue and target communities.

HEAT

Heat and heat waves may impact health services because of an increased demand on emergency services due to heat related illness and consequent increased hospital admissions. The SA Government has developed an Extreme Heat Event Plan [EHEP]. The SA Government's Communications Plan ensures that relevant, timely and accurate information, advice and warnings are disseminated to the SA community so they can keep themselves and their family, friends, neighbours and pets safe and well before, during and after future extreme heat events. While there has been a state wide focus on identifying climate factors to prepare for climate change, changes in health services in the analogue areas (e.g. at hospitals) as a response to climate factors had not been noted (Interview, UniSA Centre for Regional Engagement, 31 March 2011). A heat policy had been developed for Port Pirie Council workers (Interview, Port Pirie Regional Council, 7 December 2010). Similar policies were in operation in the target community indicating that occupational health and safety responsibilities, which are consistent across the state, determine the local action to address heat exposure for workers. At the community level, the Port Pirie Council had identified a need to develop a Swimming Pool Closure Policy to address peak capacity during hot weather indicating that the swimming pool was providing relief from heat during summer. Pool opening hours in Port Pirie during summer were 11am to 5.30pm daily except public holidays, and if weather was hotter (32°C at 5pm), the pool would open from 7pm to 9pm Sunday to Friday. The Aquatic centre operated by Port Adelaide Enfield Council offers patrons year round access to swimming facilities into the evening Monday to Thursday, and in summer the outdoor pools remain open until 6pm if the temperature is 28°C. The sandy beach coastline of Port Adelaide Enfield Council offers an alternative aquatic environment for heat relief.

DROUGHT

The analogue communities of Whyalla and Port Pirie, as well as the target communities in metropolitan Adelaide (City of Playford and City of Port Adelaide Enfield), are each served by reticulated water schemes sourced wholly or in part from the River Murray. Drought conditions in the Murray Darling Basin as well as in the Mount Lofty Ranges have resulted in water conservation measures across all areas in this study. To secure water resources at the local level, there has been an increased focus by local government and natural resources

management boards to find alternative sources of water, such as rainwater, treated stormwater and treated wastewater, including grey water, for use in gardens, for flushing toilets and watering parks and ovals. Department of Health (SA) has developed regulations for use of treated effluent (wastewater) and approves all wastewater and grey water reuse schemes to ensure that risk to health associated with the use of treated wastewaters is minimised. While drought may encourage the installation of rainwater tanks by households in communities, health aspects associated with using rainwater are important considerations. Guidance on use of rainwater tanks (Australian Government, 2004) indicates that there are a few areas where impacts from major industrial emissions (for example, Port Pirie, South Australia) mean tank rainwater is not suitable for drinking and food preparation. The guidance document refers to a survey of water and sediment samples from tanks along the rail corridor used to transport lead ore to Port Pirie, indicating that very high concentrations of lead were detected in the sediments, while most of the water samples (25 of 33) contained less than 10 µg/L (Body cited in Australian Government 2004).

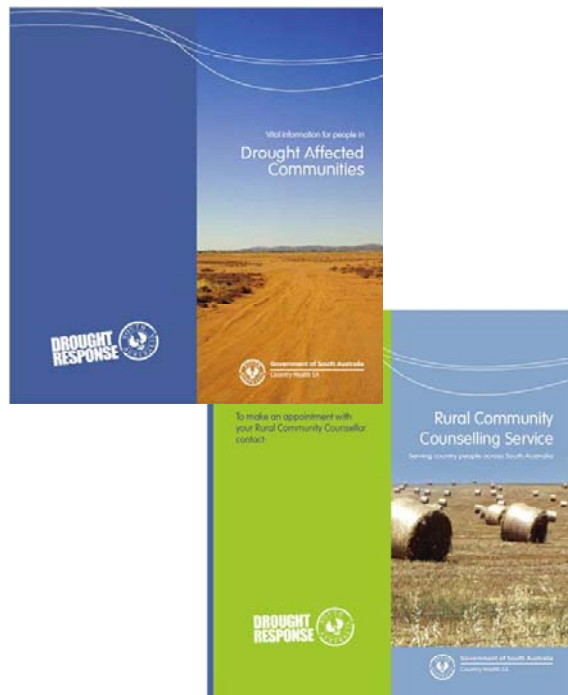
The capture and storage of stormwater in wetlands has been raised as a possible breeding ground for mosquitoes. Hence an increase in mosquitoes and vector borne diseases may be a possible consequence of seeking alternative water sources in times of drought (Interview, SA Health, 1 December 2010). Further epidemiological studies would be needed to confirm whether there has been any observed increase in vector borne diseases during drought conditions. In the Port Pirie Council area, the Environmental Health Officer conducts annual mosquito management programs between September and April. This program involves weekly monitoring of adult mosquito activity within the town and the monitoring and treatment of breeding sites that include the stormwater drainage network and the mangrove areas outside of the city. Adult trapping and identification services are also available at the council for problems with small localised mosquito populations. Kokkinn et al. (2009) have modelled the ecology of the mosquito in the coastal area around Port Pirie.

Box 2 Mental Health Services in Northern Spencer Gulf

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Box 2. Mental health services in Northern Spencer Gulf responding to drought

Department of Health (SA) has produced a brochure with information about the health impacts of drought for people in Drought Affected Communities. The brochure details services that are being provided on Eyre Peninsula and in the Northern Spencer Gulf area. These services include rural community counselling, a program for Men in Community, programs related to managing the Pressures of Farming in a drought affected community and a Drought Website for further information for support services and local rural financial counsellors. While better recognition of illness or mental health issues has been triggered by experiencing drought, the provision of these services is not restricted to communities experiencing drought (Interview, UniSA Centre for Regional Engagement, 31 March 2011). Programs are also now focusing on the needs of women in communities. Hence drought has been the catalyst for the provision of mental health and counselling services in the rural/regional communities of Whyalla and Port Pirie. While water restrictions have been experienced in Adelaide's metropolitan areas and business operators may have been affected by the drought, there was no mention of an increase in demand for health services such as mental health counselling or financial counselling resulting from drought in the metropolitan area. The knowledge acquired from the analogue communities is expected to be of increasing importance to the peri-urban target communities of metropolitan Adelaide such as City of Playford where farmers and horticulturalists rely on reliable rainfall and water resources to generate an income from the land.



Brochures for health services provided to drought affected communities including rural community counselling services (Image source: <http://www.service.sa.gov.au/subject/Water%2C+energy+and+environment/Water/Drought+response>)

Analogue communities have experienced drought conditions which have caused a review of health services in rural communities. See Box 2 for a description of the changes in mental health services triggered by drought in the analogue communities of Whyalla and Port Pirie.

BUSHFIRE THREAT

Bushfires may take place where there is fuel to burn and where weather conditions are appropriate to either start a fire or allow a fire to spread. An increased threat of bushfire may be associated with a forecast of strong wind and storms with lightning that follows a period of hot and dry weather. The native flora of South Australia – mainly eucalypts – supports bushfire, and some landscapes require bushfires to germinate or to flourish. Bushfires are handled by the Country Fire Services in regional areas or on the fringe of the metropolitan area of Adelaide. The Emergency Services relay warnings through the Bureau of Meteorology and through the local radio. Bushfires may affect air quality, making breathing difficult and hence those suffering from smoke inhalation may require health services.. In the analogue communities and in the City of Playford, local government enforces fire bans which restrict the lighting of fires during late spring, all through summer and into early autumn. The target community of City of Port Adelaide Enfield is coastal and fully developed and does not have tracts of bushland which may be susceptible to bushfire. In light of the state wide approach to the setting of bushfire seasons and the issuing of warnings in regional areas across the state, there is little difference between the analogue and

target communities in respect to the impact that bushfires may have on the type of, and demand for, health services.

HIGH VELOCITY WIND

High velocity wind may lead to falling trees or damage to property, which may then lead to injury and demand for health services. Wind can also lead to increased levels of dust in the air. In the analogue of City of Whyalla, a community dust target was set in 2008 for the OneSteel smelters to work at reducing dust emissions from their facilities. While respiratory disease has higher rates of incidence in Whyalla than in Adelaide (Interview, UniSA Centre for Regional Engagement, 31 March 2011), research into the causal factors that may indicate whether it is related to red dust or to climate, was still to be undertaken. Dust has also been identified as a health problem in Port Pirie, where it has been a direct result of one hundred years of emissions from the lead smelters. A lead monitoring study was established in the community of Port Pirie in 1984 resulting in policies and programs such as the Port Pirie Lead Implementation Program (PPLIP) focused on reducing the ingestion of lead by children and pregnant women in the Port Pirie community. A review of the PPLIP (Maynard, Franks & Malcolm 2005) stated that:

Airborne deposition of lead contaminated dust appears to be the primary pathway of contamination of Port Pirie children's living space. Dust is transported mainly through wind action, primarily by re-entrainment, from both environmental sinks around, the smelter and new fugitive emissions. Transport of airborne lead occurs principally on days of high velocity winds in association with dry conditions. Human, vehicle and material handling activities assist in dust raising. Plumes of fine particle emissions from the major processing plants are also important ongoing sources of offsite contamination' and 'Twenty four hours of winds from the direction of the smelter can produce lead deposition indoors that exceeds the US Environmental Protection Agency criterion of 500µg lead/ft² calculated as the upper floor loading limit for keeping children's blood lead below 10µg/dL (which is also the NHMRC national blood lead goal).

Neither of the target communities had identified dust from high velocity winds as a health issue, in spite of the Adelaide Brighton Cement facility at Port Adelaide (in City of Port Adelaide Enfield) having a history of depositing dust (purported to be in the order of 150 tonnes per year) on neighbouring residential areas which residents contend has caused asthma and eczema (ABC, 2004).

While there was no specific reference to protection against dust from industry during high velocity wind events, there are actions within the PAE *Public and Environmental Health Plan 2007-2012* (City of Port Adelaide Enfield, 2007) requiring council to advocate to the Environmental Protection Authority about increased monitoring for air quality related to industrial sites.

From a review of climate change risk assessment and adaptation documents, the target community of City of Port Adelaide Enfield had identified a civic centre facility as an emergency shelter place in case of severe storm or tornado.

FLOODING/INTENSE RAINFALL

Intense rainfall and flooding has been experienced in both the analogue areas of Whyalla and Port Pirie. The only reference to health services responding to flooding was in relation to flooding in the far north of the state – further north of Port Pirie noting that such flooding had affected the condition of airfield runways for use by emergency services vehicles. Flood warnings in the target communities are provided by Bureau of Meteorology while Department of Health (SA) issues warnings about the potential contamination of water bodies by flood water. Department of Health (Interview, Department of Health (SA), 1 December 2010) noted that an increased incidence of *Salmonella* may be detected after flooding events as wastewater may contaminate water supplies.

COASTAL

While the impact of climatic factors, such as coastal storm surges coupled with sea level rise on health services, has not been addressed by policies and plans for the analogue of Whyalla, the analogue of Port Pirie has specified principles and objectives relating to sea level rise to achieve public safety in its Local Development Plan (2011). The target community of Playford has identified the need to decommission onsite wastewater systems on the coastal foreshore as an environmental health strategy and to undertake a spatial analysis of coastal properties to determine impact of sea level rise and storm surge on onsite wastewater systems. The council also inspects onsite wastewater systems and proposes to undertake a service level review to increase the frequency of inspections to ascertain compliance and condition of onsite wastewater systems. There was no evidence of health services (including environmental health services) having been modified in the Port Adelaide Enfield area to address these coastal climatic factors.

SUMMARY

See Tables 8 and 9 for a summary of the analysis of health services policy and plans for response to climatic factors for Whyalla and Playford and for Port Pirie and Port Adelaide Enfield respectively. The state-led approach to addressing climatic factors within health services masks action being initiated at the local or community level and differences are not obvious. However, programs in the analogue areas are starting to address the health impacts of drought in farming communities, particularly mental health, and may offer knowledge for assisting horticulture and business operators reliant on rainfall in the target communities. While the analogue communities currently experience heat and heat waves in excess of those experienced in the target metropolitan communities, most research to date has focused on the impacts of heat and heat waves in the Adelaide metropolitan area, although the fact that more research needs to be conducted regionally has been acknowledged.

Table 8 Analysis of integration of climate factors into health services policies, plans and processes for Whyalla and Playford

Whyalla – Playford					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Whyalla State Government Extreme Heat Event Plan</p> <ul style="list-style-type: none"> Research by Uni Adelaide with SA Health Dept and SES about increased emergency service demand in heat waves (not yet analysed) 	<p>Whyalla Department of Health</p> <ul style="list-style-type: none"> regulations for use of treated effluent schools and sporting grounds - organisations upgrade their irrigation systems to comply with Department of Health regulations <p>Department of Health (SA) - Vital Information for people in Drought Affected Communities</p> <ul style="list-style-type: none"> Rural community Counselling service Men and Community Program Managing the Pressures of Farming <p>Country Health SA program</p> <ul style="list-style-type: none"> drought trigger - mental health issues - based out of Port Augusta - for Spencer Gulf Region <p>Drought Website – SA Govt www.service.sa.gov.au/drought.asp</p>	<p>Whyalla No evidence</p>	<p>City of Whyalla – Environmental Health</p> <ul style="list-style-type: none"> A community dust target set in 2008 for OneSteel respiratory disease higher rates in Whyalla than Adelaide 	<p>Whyalla No evidence</p>	<p>Whyalla No evidence</p>
<p>Playford State Government Extreme Heat Event Plan</p> <ul style="list-style-type: none"> Research by Nitschke, Tucker and Bi (2007) council inclement weather policy 	<p>Playford No evidence</p>	<p>Playford (with SA Country Fire Service and Planning SA)</p> <ul style="list-style-type: none"> Ensure that bushfire management planning policies meet changing bushfire conditions. 	<p>Playford No evidence</p>	<p>Playford Virginia Flood Safety Program</p> <ul style="list-style-type: none"> Virginia Flood - occurs every 10 years (ave) Flood warnings from BoM website Virginia Playground and Recreational Space Project (Response to flooding - for families to move forward) 	<p>Playford (Environmental Health)</p> <ul style="list-style-type: none"> inspections to ascertain compliance and condition of onsite wastewater systems. Develop an environmental health strategy for the decommissioning of onsite wastewater systems on the coastal foreshore

Table 9 Analysis of integration of climate factors into health services policies, plans and processes for Port Pirie – Port Adelaide Enfield

Port Pirie – Port Adelaide Enfield					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Port Pirie</p> <p>State Government Extreme Heat Event Plan</p> <p>Port Pirie Council</p> <ul style="list-style-type: none"> business continuity plan – lack of air-conditioning worker safety in heat 	<p>Port Pirie</p> <p>Vital Information for people in Drought Affected Communities</p> <ul style="list-style-type: none"> Rural Community Counselling service; Men and Community Program; Managing the Pressures of Farming. <p>Drought Website www.service.sa.gov.au/drought.asp</p> <p>Guidance on use of rainwater tanks - Australian Government 2004</p> <ul style="list-style-type: none"> Notes that Port Pirie has restrictions. Lead issues are exacerbated by drier conditions. <p>Port Pirie Council</p> <ul style="list-style-type: none"> Mosquito Management Plan 2010 <p>The Mosquitoes and Public Health Research Group</p> <ul style="list-style-type: none"> three month forecasts of mosquito borne virus risk in SA 	<p>Port Pirie</p> <ul style="list-style-type: none"> Annual Fire Ban Season - 15 November to 30 April 	<p>Port Pirie</p> <p>CAR Adaptation Strategy (Tenby10 Strategy)</p> <ul style="list-style-type: none"> To minimise the impacts of dust related health issues. Lead issues are exacerbated by drier conditions. 	<p>Port Pirie (Council and SES)</p> <ul style="list-style-type: none"> Community education and awareness program 	<p>Port Pirie</p> <p>Development Plan, August 2008</p> <ul style="list-style-type: none"> Specified principles and objectives relating to sea level rise to achieve public safety
<p>Port Adelaide Enfield</p> <p>State Government Extreme Heat Event Plan</p> <ul style="list-style-type: none"> Research by Nitschke, Tucker and Bi (2007) <p>Port Adelaide Enfield Council</p> <ul style="list-style-type: none"> Adequate controls for reducing extreme heat hazards for all staff 	<p>Port Adelaide Enfield (The Mosquitoes and Public Health Research Group)</p> <ul style="list-style-type: none"> three month forecasts of mosquito borne virus risk in SA 	<p>Port Adelaide Enfield</p> <p>No evidence</p>	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> for major storm in council area e.g. Tornado - Potential Community Shelter Accommodation - Civic Centre 	<p>Port Adelaide Enfield Dept Health</p> <ul style="list-style-type: none"> Flood warning report – drinking water 	<p>Port Adelaide Enfield</p> <p>No evidence</p>

2.2.5 Ecosystem services

Ecosystems provide economic and social benefit (services) to humans which may be explicit e.g. from agricultural, horticultural, aquacultural and recreational uses, or implicit in that humans may be unaware of the services being provided. In South Australia, ecosystems are managed by state and regional agencies in conjunction with local government and local community groups. Legislation is set at the state level, with policies and plans then developed for a regional natural resources management approach. During the course of this study, a reorganisation of state government departments has taken place, resulting in the establishment of a Department of Environment and Natural Resources (DENR), although there is a separate Department for Water which addresses water allocation and water security in South Australia. At the regional level there are eight natural resource management (NRM) boards in operation across the state. The Whyalla analogue is at the northern end of the Eyre Peninsula (EP) NRM Board Region, the Port Pirie analogue is within the Northern and Yorke (NY) NRM Board Region. The Adelaide metropolitan target communities are both within the Adelaide and Mount Lofty Ranges (AMLR) NRM Board Region. For each of these regions, plans have been developed to preserve and enhance natural resources including water, soil, flora and fauna, both on land and in surface water and marine environments.

A sectoral agreement approach pioneered by EP NRM Board is a first in Australia and is considered to be a strength as individual councils in the EP NRM Region lack knowledge and resources (Department of the Premier and Cabinet, 2009).

HEAT

The impact of heat on terrestrial ecosystems may relate to the type of garden plants and the type of street trees that can be sustained in urban areas as well as in natural habitats such as those found in National Parks, state, regional or local parks, or constructed ecosystems for community recreational use. A visual inspection of residential areas by members of the research project team indicated that Whyalla citizens were adapting to high temperatures and low water availability by removing grass and replanting gardens with native species. However, a 30% dieback of native species used for street trees and in parks had also been observed, resulting in the Whyalla Council employing a team of nine workers whose sole job is the removal of dead trees (Interview, City of Whyalla, 29 November 2010). Anecdotal comments from the EP NRM Board Chair noted a similar rate of dieback of mostly red gum trees occurring on his farming property, which may indicate that the boundary of the climatic zone that supported the growth of these native tree species in the past has shifted. For the Port Pirie analogue area, concern was expressed about the sensitivity to change in temperatures of the Upper Spencer Gulf marine area, including the resultant impact on shell fish (prawns) and economically sustainable fishing practices. A workshop was on ecology and climate science in the region (Interview, Port Pirie Regional Council, 7 December 2010).

In the target communities, heat was recognised as an issue to be addressed in climate change adaptation plans and strategies. The City of Playford identified the potential for council-owned water bodies to increase in turbidity and algae growth during periods of extreme heat, thereby requiring a review of its program for monitoring water bodies and assessing alternative water aeration techniques to counter adverse health impacts. The council has committed to developing an open space strategy and to reviewing its *Planting Policy* to include an impact assessment of surrounding heat absorbing structures that have the potential to increase mortality of new plantings; the timing of planting and plant selection by monitoring ongoing condition and growth of native species and investigating further application of arid zone plants.

DROUGHT

The SA government has established a Drought Website (Government of South Australia, 2009) which provides access to a wide range of drought related information including support services, local rural financial counsellors and advice for maintaining land condition.

At the regional level, water resources are defined as 'The total amount of water that is available to supply the needs of all water users, including water-dependent ecosystems, irrigators and other human consumers. This includes water in watercourses, lakes, surface water (including stormwater), and effluent' (Northern Adelaide and Barossa Catchment Water Board 2000).

For the analogue community of Port Pirie, at a regional level, the Beetaloo and Baroota reservoirs, with a total capacity of 9,000 ML, are currently isolated from the SA Water reticulation system which services the region and are retained for emergency use. Some use of Baroota water for irrigation is taking place although there is limited opportunity for expansion. The N&Y NRM Board is preparing a water allocation plan for the Baroota Prescribed Areas. Monitoring of River Red Gums has been proposed as an indicator of ecosystem health. There have also been changes from crops to grazing in marginal farming enterprises (Interview, Port Pirie Regional Council, 7 December 2010). While the low stocking rates in the Mambray Coast region are thought to have limited any major physical damage to watercourses in this area (Deane et al. 2005), a reduction in surface water run-off due to less rainfall may have led to increased siltation of many watercourses of the Mambray Coast (Deane et al. 2005). The N&Y NRM Board State of the Region 2009 document (p. 40) notes that there are complexities of managing water in a broadly semi-arid environment. It notes that groundwater is the most important resource for the vast majority of users, yet is inherently difficult to quantify and model effectively, particularly in the fractured rock aquifers which dominate the region. Lack of long-term scientific data is compounded by a highly variable system (Favier et al. 2004).

For the analogue of Whyalla having a 'good' quality of life, it relies on being seen as green rather than arid. As a result of drought conditions, the Whyalla community has sought to utilise alternative sources of water and has developed infrastructure to use more urban storm water and treated wastewater. Wetland ecosystems have been constructed for treating stormwater for aquifer storage and recovery (ASR) as part of its water recycling practice. Recreational areas, such as the golf course, are irrigated with recycled water. The private gardens in Whyalla have been adapted to low water availability by citizens removing high water use plants, such as lawn and grass, and replanting with native species. In spite of drought conditions, mosquito populations are still a concern and have continued to be studied in the coastal environments of both analogue communities (for Whyalla coastal area, see Williams et al. 2009 and for Port Pirie coastal area, see Kokkinn et al. 2009).

In the target community of Port Adelaide Enfield, major ASR schemes have been implemented at Regent Gardens and Northgate. Regent Gardens is a residential development located 8 km northeast of the Adelaide CBD. Northgate is a major greenfield residential development that includes a five-lake stormwater retention facility and an ASR scheme which has attracted international recognition. A new ASR scheme is also being investigated for development within the Barker Inlet Wetlands, in conjunction with SA Water. In the City of Playford, there is a focus on the use of water saving products and a review of the plant watering schedules in council-maintained areas. A long term asset management plan has also proposed the installation of sustainable sub-surface irrigation systems to open space and sporting reserves that have been assessed to have high community value. At the regional level, the AMLR NRM Board is mapping land degradation in rural areas and developing a program of works to address drought and land degradation.

While there are examples of water conservation and water recycling evident in the analogue communities to reduce stress on plant ecosystems that provide services to humans, schemes that reduce impact on drought affected water resources, such as the River Murray, are also

evident in the target communities. While both analogue and target communities are reviewing plant species used as street trees and for use in parks and gardens to accommodate less rainfall, the policies developed in the Northern Spencer Gulf communities provide learning for target communities. Some of this knowledge is discussed in Box 3.

Box 3. Programs for replacing dying trees and managing public open spaces

The Whyalla Council is reviewing plant species and is developing a landscape plan for its council-maintained areas. A 30% die back of native species used for street trees and in parks was observed, resulting in the Whyalla Council employing a team of nine workers whose sole job was the removal of dead trees (Interview, City of Whyalla, 29 Nov 2010). Tree species selection has been an integral part of developing a tree maintenance database where complete records of maintenance for each tree are available.

Similarly, the Port Pirie Council has developed a replacement plan for Council vegetation and irrigation equipment. The Council's Vegetation Planting Policy reflects priority and preferences for a selection of local indigenous drought tolerant species, reviewing plant location and watering regimes. The Port Pirie Council recommends that rural roadside vegetation consist of local plant species using seed collected locally, or other species suitable for the climatic and soil conditions. Procedures have been adopted for monitoring the condition of vegetation for stress and impacts from pests and diseases and strategies have been developed for monitoring turf condition and closing sporting fields that become 'unfit' for purpose.

The Port Pirie Council, in conjunction with Nyrstar (the operators of the lead smelter in Port Pirie), has recently won a grant for water reuse in Port Pirie which would see Nyrstar treating water used through the plant for both Nyrstar reuse and a component made available to Council for use on public spaces. Detailed planning for the project was budgeted to commence in 2010/11.



Port Pirie with the Nyrstar lead smelters in foreground (Image source:

<http://www.ret.gov.au/energy/Documents/energyefficiencyopps/PDF/Industry%20Case%20Study%20N>

BUSHFIRE THREAT

While the analogue of Whyalla does not consider itself to be in a bushfire prone area, the Port Pirie Council Vegetation Planting Policy notes preference for selection of local indigenous bushfire tolerant species which may indicate that bushfires are to be expected.

In the target community of City of Playford, the Little Para Water Catchment area (SA Water reserve) and surrounding properties are noted as common locations for lightning strikes, which are a common cause of bushfire. The SA Department for Environment and Heritage (now DENR) undertakes slashing, mowing, grazing and fire track maintenance within its areas in accordance with its Fire Prevention Plan and Fuel Reduction Policy (City of Playford, 2010b). Transport SA have a roadside spraying, slashing and grading program to protect signposts, guideposts and roadside reserves and also maintain hazard reduced depots. In the target community of City of Port Adelaide Enfield, the main area at risk of bushfire is considered to be the terrestrial areas within the Barker Inlet Wetlands. The City of Port Adelaide Enfield does not open the wetland to the general public but do conduct sunset tours during November to January (Waterwatch Central Adelaide n.d.)

HIGH VELOCITY WIND

In the analogue communities, the impact of wind on ecosystem services was in relation to wind erosion of agricultural soil. A Wind Erosion Risk Index has been developed and is monitored by state government (now DENR) (Northern and Yorke Natural Resource Management Board 2009). Soil cover and disturbance on susceptible soils is used to indicate the Erosion Risk Index (ERI) of soil. The ERI gives an average number of days each hectare of susceptible soil is at risk of erosion on a yearly basis. Alternatively, the figure can be re-calculated to indicate the average number of days the soil was protected. A theoretical minimum ERI of 15 days could be achieved on cropping land using direct drill technologies. Since 1999, the average Wind ERI for agricultural land susceptible to wind erosion in the Nand Y NRM area was 70 days per year (it was protected for 295 days). The Wind ERI has decreased slightly over this period indicating that practices have slightly improved the protection of soil.

The target community of Playford includes agricultural and horticultural land which may have reduced productivity due to high wind velocity and erosion. However, in a review of council documents, the main reference to high velocity wind and impact on ecosystems in each of the target communities was in relation to storm damage to council trees. There was no specific management response that focused on protecting ecosystem services noted.

FLOODING/INTENSE RAINFALL

For the analogue of Port Pirie, at a regional level, the *Waterwatch* monitoring of water in the Broughton River indicated high turbidity and high phosphorous levels during high flow events with a high variability in salinity levels (Northern and Yorke Natural Resource Management Board 2009; Favier et al. 2004). The *Port Pirie Draft Structure Plan 2009* notes that water ecosystems play a critical role in the region, providing flood mitigation and scenic amenity, as well as supporting biodiversity. A Tidal Flood Mitigation Infrastructure Report for the City of Port Pirie published in 1991 and based on work undertaken by Lange Dames and Campbell Pty. Ltd. (1991) led to the 'construction of protective works across the supratidal flats' (Harvey et al. 1997, p.5).

In the target communities of metropolitan Adelaide, the AMLR NRM Board, in partnership with local government, develops stormwater master plans for urban areas of the region. The AMLR NRM Board works with local government to facilitate an increase in awareness of flood risk and implement flood mitigations works. In the City of Port Adelaide Enfield, a detailed mapping study of the Lefevre Peninsula and Barker Inlet area has taken place. In the target community of City of Playford, a Virginia Flood occurs on average, once every 10 years, impacting horticultural enterprises. Flood water management is a key environmental issue in northern urban development and affects the western plains to the coast. Flood plain mapping of the Gawler River and Thompson Creek has been undertaken by the AMLR NRM Board in conjunction with local government. The Gawler River Flood Mitigation Strategy has been developed and implemented in conjunction with the Gawler River Flood Management Authority, which involves a partnership of six constituent councils (including City of Playford). In 2007, The Gawler River Floodplain Management Authority (GRFMA) received a report by the Department for Transport, Energy and Infrastructure containing new hydrological data for the Gawler River Flood Plain area. It was stated that 'This report may result in the boundaries of the flood risk area being amended'.

COASTAL

The specific services provided by the coastal ecosystems in the Upper Spencer Gulf, relate to Yellowtail Kingfish aquaculture developments largely around Port Augusta and Fitzgerald Bay

near Whyalla and the protection to the coastal communities by mangroves and salt marshes in the Spencer Gulf during storm surges and high tides. As sea levels rise due to climate change, these coastal ecosystems are expected to move inland, although the extent of movement relies upon the availability of land and the lack of barriers to such movement (Townsend cited by Jenkin 2007). The management of the coastal zone is a responsibility of the state through the Coast Protection Board. Action to address coastal impacts on ecosystem services has been limited to sand replenishment programs, sand dune and beach stabilisation projects and advocacy for coastal planning policy to acknowledge the impact of sea level rise. In the analogue area of Port Pirie, tidal flooding and coastal vulnerability studies were undertaken (see Harvey et al. 1997). Based on these studies, response included construction of protective works across the supratidal flats, indicating that the existing coastal ecosystems do not provide adequate protection to the community during tidal surge events. Geological uplift in the coastal area was also noted by Harvey and Belperio (1994), which complicates the contribution of climatic factors to coastal ecosystems protecting the community. There were no other management responses related to climatic coastal effects on ecosystem services noted in the analogue areas.

In the target communities of metropolitan Adelaide, the coastal area encompasses a critical natural fish nursery and 'grow-out' sites in the tidal and estuarine areas of the Barker Inlet coast, which support the multi-million dollar SA commercial and recreational fishing industry (City of Port Adelaide Enfield, 2008). Key tourism assets and the state government's legislated Adelaide Dolphin Sanctuary are also contained in large part in the City of Port Adelaide Enfield's coastal area. The regional approach undertaken by the AMLR NRM Board provides coastal planning and on-ground works to manage and conserve priority coastal habitats. Responses to the impacts of climatic factors are however less evident in plans that deliver action on the ground. As an example, large tracts of land at Gillman have been identified for immediate industrial development, however, this land has been a tidal flood plain accommodating ecologically valuable samphire and mangrove habitats that will be under threat from sea level rise unless migration/retreat buffers are in place. These buffers are not currently planned for by the state's planning authority or the state's land management agency releasing the land. Other services provided by coastal ecosystems include the constructed wetlands in Gillman that treat the majority of northwestern Adelaide's stormwater prior to discharge to the coast. These wetlands are also key biodiversity assets, with several migratory bird species protected by international treaty. The impact of sea level rise is still to be addressed in the management of these wetlands.

From the analysis of policy and plans to protect the ecosystem services of the coastal zone in each of the analogue and target communities, differences are not detected because the state led approach of the Coast Protection Board and the regional NRM approaches are similar. The impact of local coastal climatic factors is also complicated by geological processes occurring along the coastlines.

SUMMARY

See Tables 10 and 11 for a summary of the analysis of ecosystem services policy and plans for response to climatic factors for Whyalla and Playford and for Port Pirie and Port Adelaide Enfield respectively. There are opportunities for the target communities to learn from the approaches to removing trees and planting drought tolerant species as undertaken by both the Whyalla and Port Pirie analogue Councils. While many local actions are masked by state level policy and planning, the Eyre Peninsula Regional Sector Agreement *Pursuant to the South Australian Climate Change and Greenhouse Emissions Reduction Act 2007* provide a regional approach toward managing the impact of climatic factors on natural resources and ecosystem services in the analogue area of Whyalla. This regional approach is seen as a strength because individual councils lack knowledge and resources to study issues and develop policy on their own.

Table 10 Analysis of integration of climate factors into ecosystem services policies, plans and processes for Whyalla and Playford

Whyalla – Playford					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Whyalla</p> <ul style="list-style-type: none"> • Citizens are adapting to heat by turning gardens into native planted areas and getting rid of grass. 	<p>Whyalla</p> <ul style="list-style-type: none"> • 30% dieback of native species. Council employs a team of nine whose sole job is the removal of dead trees. • Wetlands and water recycling – well developed in Whyalla because of necessity. • Aquifer recharge. Golf course irrigated with recycled water. <p>Williams et al. - Mosquito ecology research</p>	<p>Whyalla</p> <p>Not considered to be in bushfire area</p>	<p>Whyalla</p> <ul style="list-style-type: none"> • Wind Erosion Risk Index is monitored by state Govt (DENR) 	<p>Whyalla</p> <p>No evidence</p>	<p>Whyalla Coast Protection Board</p> <ul style="list-style-type: none"> • significant sand loss (1 metre) - new sand banks appearing out at sea. <ul style="list-style-type: none"> ◦ result of recent storm events • retention bank built in 1950s is being undermined as a result.
<p>Playford</p> <ul style="list-style-type: none"> • Water quality testing meet the needs during increased extreme heat events • Alternative water aeration techniques that can be installed in council-owned water-bodies to decrease turbidity and limit algae growth. 	<p>Playford</p> <ul style="list-style-type: none"> • Assess impact on council operations. • Advocate for appropriate research and investigation on the impacts that reduced average rainfall will have on the viability of the horticulture industry on the Adelaide Plains. 	<p>Playford SA Water</p> <ul style="list-style-type: none"> • Little Para Water Catchment area - common location for lightning strike - common cause of fire. <p>DENR (now)</p> <ul style="list-style-type: none"> • slashing, mowing, grazing and fire track maintenance within its areas in accordance with their Fire Prevention Plan and fuel reduction policy <p>Transport SA</p> <ul style="list-style-type: none"> • roadside spraying, slashing and grading program to protect signposts, guideposts and roadside reserves, and also maintain hazard reduced depots 	<p>Playford</p> <p>No evidence</p>	<p>Playford Virginia Flood Safety Program</p> <ul style="list-style-type: none"> • Virginia Flood - occurs every 10 years on average • growers impacts • flood water management - key environmental issue in northern urban development and western plains to the coast 	<p>Playford AMLR NRM Board</p> <ul style="list-style-type: none"> • coastal planning and on-ground works <p>City of Playford</p> <ul style="list-style-type: none"> • review and update Drainage Management Policy to incorporate sea level rise and storm surge as key impacts on stormwater and drainage.

Table 11 Analysis of integration of climate factors into ecosystem services policies, plans and processes for Port Pirie and Port Adelaide Enfield

Port Pirie – Port Adelaide Enfield					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Port Pirie</p> <ul style="list-style-type: none"> analysis of Council Community Land – identify type and condition of trees, shrubs, turf and other vegetation – tree replacement monitoring turf condition and the closure of sporting fields that become 'unfit' for purpose 	<p>Port Pirie</p> <ul style="list-style-type: none"> analysis of Council Community Land – identify type and condition of trees, shrubs, turf and other vegetation – tree replacement monitoring turf condition and the closure of sporting fields that become 'unfit' for purpose 	<p>Port Pirie Council Vegetation Planting Policy</p> <ul style="list-style-type: none"> reflects priority and preferences for selection of local indigenous drought and bushfire tolerant species, plant location and watering regimes 	<p>Port Pirie N and Y NRM Plan - State of the Region 2009</p> <ul style="list-style-type: none"> since 1999, the average Wind ERI for agricultural land susceptible to wind erosion was 70 days per year (it was protected for 295 days). The Wind ERI has decreased slightly over this period. 	<p>Port Pirie N and Y NRM Plan - State of the Region 2009</p> <ul style="list-style-type: none"> Since 1999, the average Water ERI for agricultural land susceptible to water erosion was 79 days per year (it was protected for 286 days). The Water ERI has increased slightly over this period. <p>N&Y NRM Plan 2009 - Broughton River</p> <ul style="list-style-type: none"> Waterwatch monitoring (see Favier et al. 2004). 	<p>Port Pirie Lange Dames and Campbell Ply. Ltd. (1991). Tidal Flooding Study, for the City of Port Pirie</p> <ul style="list-style-type: none"> 'construction of protective works across the supratidal flats.' (Harvey et al. 1997:5)
<p>Port Adelaide Enfield No evidence</p>	<p>Port Adelaide Enfield</p> <ul style="list-style-type: none"> Major ASR schemes have been implemented at Regent Gardens and Northgate 	<p>Port Adelaide Enfield Emergency Response Plan</p> <ul style="list-style-type: none"> bushfire in council area - wetlands area only 	<p>Port Adelaide Enfield Emergency Response Plan</p> <ul style="list-style-type: none"> Storm damage by council trees 	<p>Port Adelaide Enfield BoM</p> <ul style="list-style-type: none"> Flood Warning Report <p>AMLR NRM</p> <ul style="list-style-type: none"> Floodplain Mapping <p>Port Adelaide Enfield Council</p> <ul style="list-style-type: none"> detailed mapping study of the Lefevre Peninsula and Barker Inlet area 	<p>Port Adelaide Enfield Barker Inlet Wetlands, Gillman</p> <ul style="list-style-type: none"> constructed - treats majority of northwestern Adelaide's stormwater prior to discharge to the coast <p>AMLR NRM Board</p> <ul style="list-style-type: none"> coastal planning <p>City of Port Adelaide Enfield</p> <ul style="list-style-type: none"> submission - Coastal Impacts of Climate Change <p>State Government's</p> <ul style="list-style-type: none"> Adelaide Dolphin Sanctuary

2.3 LIST OF REFERENCES – SOUTH AUSTRALIA

Table 12 Summary of references for South Australian pairings

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
STATE							
Coast Protection Board, South Australia, 2009. <i>Coastal Protection Board Strategic Plan 2009-2014</i> , Government of South Australia, Adelaide.	Eco						#
Coast Protection Board, South Australia, 1992. <i>Coastal Erosion, flooding and sea level rise standards and protection policy</i> , Government of South Australia, Adelaide. <i>Coastline</i> , 26.	LUP						#
Department of Planning and Local Government, 2010a., <i>The South Australian Planning Strategy – The 30-Year Plan for Greater Adelaide</i> , Government of South Australia, Adelaide. http://www.dplg.sa.gov.au/plan4adelaide/html/files/plan/The_30-Year_Plan_for_Greater_Adelaide.pdf	LUP, Inf		#			#	#
Department of Transport and Urban Planning, 2007. <i>The Planning Strategy for Regional South Australia</i> Government of South Australia, Adelaide. http://www.planning.sa.gov.au/go/planning-strategy	LUP, Inf		#			#	#
Department for Transport, Energy and Infrastructure, 2005a. <i>Strategic Infrastructure Plan for South Australia</i> , Government of South Australia, Adelaide. http://www.infrastructure.sa.gov.au/_data/assets/pdf_file/0017/5192/Infrastructure_Whole.pdf	Inf		#			#	
Department for Transport, Energy and Infrastructure, 2005b. <i>Regional Overview: Strategic Infrastructure Plan for South Australia</i> , Government of South Australia, Adelaide. http://210.247.132.180/alt-host/assets/pdf_file/0011/5204/Regional_Whole.pdf	Inf		#				

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Government of South Australia, 2009. <i>Drought Response</i> , http://www.sa.gov.au/subject/Water%2C+energy+and+environment/Water/Drought+response	Health, Eco		#				
The Local Government Association of South Australia and the LGA Mutual Liability Scheme 2010. <i>Local Government Climate Adaptation Program – Interim Report May 2010</i> , Government of South Australia, Adelaide.	Inf,	#	#	#	#	#	#
ANALOGUE – PORT PIRIE							
ABC 2004. Blood Levels on the Rise in Port Pirie, 13 September, ABC News http://www.abc.net.au/sa/stories/s1196282.htm	Health, Inf				#		
Australian Government 2004. <i>Guidance on use of rainwater tanks</i> , enHealth Council, http://www.dhs.vic.gov.au/nphp/enhealth/council/pubs/pdf/rainwater_tanks.pdf	Health		#				
Burfitt, Ian 2007. <i>Port Pirie Regional Council: Climate Change Issues</i> , Presentation to Planning Institute of Australia, SA Division, 9 March.	Inf					#	#
Deane, D., Phipps, L. & Magarey, P.D. 2005. <i>Ecological condition assessment: Streams of the Mambay Coast</i> , Report DWLBC 2005/36, Department of Water, Land and Biodiversity Conservation.	Eco		#				
Department of Planning and Local Government 2011. <i>Port Pirie Development Plan</i> . Government of South Australia, Adelaide.	LUP	#	#	#	#	#	#
Favier, D., Scholtz, G., Vanlaarhoven, J., Bradley, J., Phipps, L. 2004) <i>A River Management Plan for the Broughton Catchment</i> . Government of Australia, Department of Water, Land and Biodiversity Conservation.	Eco					#	
Harvey, N, Clouston, E and Carvalho, P. 1999. Improving Coastal Vulnerability Assessment Methodologies for Integrated Coastal Zone Management: an Approach from South Australia. <i>Australian Geographical Studies</i> , 37:50-69.	Eco					#	

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Harvey N., Belperio A. 1994. Implications of climate change for the South Australian coastline. <i>Transactions of the Royal Society of South Australia</i> , 118:45-52	Eco						#
Hughes P.R. 2010. <i>Wind-Powered Desalination Could Provide Jobs Boom For Port Pirie</i> , 9 March. http://www.hughespr.com.au/news/news-archives/186-wind-powered-desalination-could-provide-jobs-boom-for-port-pirie	Inf		#		#		
Jenkin, C. 2007. 'Riding the rise', <i>The Advertiser</i> Part 10, http://www.1degree.com.au/files/AdvertiserPartworks_Part10_Page10.pdf	Eco						#
Kokkinn, M., Duval, D., & Williams, C. 2009. Modelling the ecology of the coastal mosquitoes <i>Aedes vigilax</i> and <i>Aedes camptorhynchus</i> at Port Pirie, South Australia. <i>Medical and Veterinary Entomology</i> 23:85-91	Health, Eco		#				#
Lange Dames & Campbell Pty. Ltd. 1991. <i>Report on Drainage & Tidal Flooding Study and Schematic Designs & Cost Estimates for Drainage & Mitigation Works at Port Pirie Vol 1 & 2</i> , Prepared for the City of Port Pirie, Coast Protection Board and Dept of Road Transport, July 1991.	Eco					#	
Maynard, E., Franks, L. and Malcolm, M. 2005. <i>Port Pirie Lead Implementation Program – Future Focus and Directions</i> . Department of Health, Government of South Australia.	Health				#		
Planning SA 2008. <i>Mid North Regional Land Use Framework</i> , Government of South Australia, Adelaide. http://www.planning.sa.gov.au/index.cfm?objectid=E3CFD92A-F203-0D46-ACA87623469378BC	LUP		#	#		#	#
Port Pirie Regional Council 2010b. <i>Annual Business Plan 2010 – 2011</i> http://www.pirie.sa.gov.au/webdata/resources/files/Adopted_Annual_Business_Plan_2010_1_1.pdf	Inf		#				
Port Pirie Regional Council 2009. <i>Minutes of Ordinary Meeting</i> dated 28 October.	Health	#					
Port Pirie Regional Council 2006 <i>Road Management Plan</i> , 18 August.	Inf	#	#			#	

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Tonkin Consulting 2008. <i>Crystal Brook Community Wastewater Management Scheme</i> . Prepared for Port Pirie Regional Council. November 2008 http://www.pirie.sa.gov.au/webdata/resources/files/CB_CWMS_Nov_08.pdf	Inf,		#				
TARGET – PORT ADELAIDE ENFIELD							
ABC 2004. 'Dusty Suburb', <i>Earthbeat</i> , 20 November http://www.abc.net.au/rn/science/earth/stories/s1247178.htm	Health				#		
City of Port Adelaide Enfield (n.d.), <i>Emergency Response Plan</i>	H/B						#
City of Port Adelaide Enfield 2010. <i>Emergency Response Plan</i> , 22 October, Issue No 20. http://www.portenf.sa.gov.au/webdata/resources/files/Emergency_Response_Plan.pdf	Inf, H/B			#			
City of Port Adelaide Enfield 2008. <i>Inquiry into climate change and environmental impacts on coastal communities</i> http://www.aph.gov.au/house/committee/ccwea/coastalzone/subs/sub059.pdf	Eco						#
City of Port Adelaide Enfield 2007. <i>Public and Environmental Health Plan 2007-2012</i> .	Health				#		
Department of Health (SA) 2009. <i>'Heatwaves and your health'</i> , Public Health Fact Sheet, Government of South Australia, Adelaide	Health	#					
Department of Planning and Local Government 2010b. <i>Port Adelaide Enfield Development Plan</i> . Government of South Australia, Adelaide.	LUP, H/B	#	#			#	#
Hansen, A., Bi, P., Nitschke, M., Ryan, P., Pisaniello, D. and Tucker, G. 2008 The effect of heat waves on mental health in a temperate Australian city, <i>Environmental Health Perspectives</i> , Vol 116, No 10, Oct	Health	#					
Nitschke, M., Tucker, G. and Bi, P. (2007), Morbidity and mortality during heatwaves in metropolitan Adelaide. <i>Medical Journal of Australia</i> . 187(11/12 - 3/17):662-665.	Health	#					

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Tonkin Consulting 2005. <i>Port Adelaide Seawater Stormwater Flooding Study</i> . http://www.climatechange.gov.au/publications/coastline/~media/publications/coastline/5fsection517SA.ashx	Inf					#	#
Waterwatch Central Adelaide (n.d.), <i>Barker Inlet Wetlands</i> , Adelaide Mount Lofty Ranges Natural Resource Management Board and KESAB.	Eco			#			
ANALOGUE – WHYALLA							
ABC News 2007. <i>SA, Vic towns overwhelmed by floods</i> , 20 January.	Inf					#	
City of Whyalla 2010a. <i>Annual Report 2009-2010</i> ,	Inf		#			#	
Department of Planning and Local Government 2010c. <i>Whyalla Council Development Plan</i> . Government of South Australia, Adelaide	LUP	#	#	#	#	#	#
Williams, S.R., Kokkinn, M.J., Fricker, S.R., Schneemilch, M.J., Humphrey, M.J., & Williams, C.R. 2009. Mosquitoes (Diptera: Culicidae) of the Spencer Gulf Coast of South Australia. <i>Transactions of the Royal Society of South Australia</i> , 133:51-56.	Eco		#				
TARGET – PLAYFORD							
City of Playford 2011. <i>Waterproofing Northern Adelaide</i> . http://www.playford.sa.gov.au/site/page.cfm?u=413	Inf		#				
City of Playford 2010a. <i>Parks and Recreation – Asset Management Plan 2011-2012</i> .	Inf	#					
City of Playford 2010b. <i>Playford District Bushfire Prevention Plan</i> . http://www.playford.sa.gov.au/webdata/resources/files/Bushfire_prevention_plan_2010.pdf	Inf, Eco			#			
Department of Health (SA) 2009. 'Heatwaves and your health', Public Health Fact Sheet, Government of South Australia, Adelaide.	Health	#					

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Department of Planning and Local Government 2010. <i>City of Playford Development Plan</i> Government of South Australia, Adelaide.	LUP	#	#	#		#	#

3 QUEENSLAND

3.2 TARGET AND ANALOGUE PAIRS

One analogue/target pairing was studied for Queensland. These local government areas are described in the following sections. Unless otherwise stated, all statistics are sources from the Australian Bureau of Statistics 2006 Census.

3.2.5 Gladstone Regional Council

Gladstone, Queensland, is located approximately 500km north of Brisbane. The Gladstone Regional Council is 10,489.2 km². The council area consists of the regional city centres of Gladstone and Tannum Sands/Boyne Island, as well as smaller rural towns, including Agnes Water, Ambrose, Baffle Creek, Benaraby, Bororen, Builyan, Calliope, Lowmead, Miriam Vale, Mount Larcom, Many Peaks, Nagoorin, Raglan, Rosedale, Seventeen Seventy, Turkey Beach, Ubobo and Yarwun (Gladstone Regional Council 2010a).

In 2009, the total regional population consisted of 59,644 people. This was compared to 53,941 people in 2006. 23.7% of the population was aged between 0 to 14 years old, with 8.3% of the populace over the age of 65. The region appears to contain a high transient population, with 55.2% of people in the region currently living in a different address than in 2001.

The Gladstone Region is a major industrial base supported by the state government, through the Gladstone State Development Area. This includes 'two of the world's largest alumina refineries, Queensland's largest multi commodity port' and the 'fledgling Liquefied Natural Gas (LNG) industry'. Other key industries and economic drivers of the Gladstone region include coastal tourism (Gladstone Regional Council 2010b).

The current Gladstone Regional Council was formed on 15 March 2008, through the amalgamation of the former Calliope Shire Council, Miriam Vale Shire Council, Gladstone City Council and the Gladstone Calliope Aerodrome Board (Gladstone Regional Council 2010b).

3.2.6 Moreton Bay Regional Council

Moreton Bay Regional Council, Queensland is located 45km from the Brisbane Central District. The council is 2,036.8 km² in area, and with its close proximity to Brisbane, contains dormitory, residential suburbs for the capital city. The area also serves as the location of the Port of Brisbane. The region contains the Brisbane and Pine rivers.

In 2009, the total council population consisted of 371,162 people. This is compared to a population of 332,862 people in 2006. In 2006, 21.9% of the population was aged between 0 to 14 years old, with 12.1% of the population over the age of 65. 43.6% of the total population lived at different address in 2001. The Moreton Bay Regional Council is the third largest council area in population in Australia, after the City of Brisbane and the Gold Coast (Moreton Bay Regional Council 2011a).

Other key industries and economic drivers of the Moreton Bay Regional Council, apart from residential living and port facilities, include a fledgling commercial sector and tourism.

The current City of Moreton Bay Regional Council was formed in 2008, through the amalgamation of the City of Redcliffe, the Shire of Caboolture and the Shire of Pine Rivers.

3.3 POLICY ANALYSIS

3.3.5 Land use planning

Planning is carried out under the framework of the *Sustainable Planning Act 2009* which replaced the *Integrated Planning Act, 1997* in December 2009. The State Department of Infrastructure & Planning carries responsibility for local government, planning and infrastructure. Land Use planning is governed at state level using State Planning instruments which set out policy directions in a range of areas, predominantly concerned with infrastructure. There are four state planning instruments which may be used to evaluate development proposals:

- state planning regulatory provisions
- regional plans
- state planning policies
- standard planning scheme provisions.

Queensland is divided into 73 local council areas which make decisions on development applications. Currently there are 11 planning regions most of which incorporate a number of local government areas. Regional Planning policies, in most cases, take precedence over policies at lower levels of the planning hierarchy, but may be subject to state wide policies.

The planning system is characterised as a performance based system, such that developments are evaluated against a range of relevant criteria which set benchmark performance standards. These are mostly set out in tables and other provisions in local planning schemes such as the *Gladstone Planning Scheme* (also known as the *Gladstone Plan*) or the *Caboolture ShirePlan* (part of the *Moreton Bay Planning Scheme*). Local planning schemes are currently undergoing review as result of local government reform. Broader policy statements and objectives are expressed at the regional level, setting the rationale and context for the detailed performance standards. State wide *Standard Planning Scheme Provisions* specify mandatory structure, format, administrative definitions, standard zones and codes and a suite of standard overlays which apply across Queensland.

Regional plans form the key statutory planning policy and form the focus of the analysis which follows. Gladstone is incorporated into the Central Queensland Region, and Moreton Bay into the South East Queensland Region. Policy statements relating to the land use planning response to climate change are most likely to be found at the regional planning level. In the discussion which follows, planning policy statements from both the regional level and the local planning scheme are discussed. In Gladstone there are currently three planning schemes in force covering the local government area, namely the Calliope, Gladstone and Miriam Vale Planning Schemes. For the sake of example, all local planning scheme references are to the existing *Gladstone Planning Scheme*, which will eventually be superseded by a new planning scheme covering all three former local government areas (see Gladstone Regional Council 2010c). Similarly Moreton Bay is currently preparing a new Moreton Bay planning scheme which will supersede the existing Caboolture, Pine Rivers and Redcliffe planning schemes. Examples here are drawn from the existing Caboolture scheme.

The *Central Queensland Regional Growth Management Framework* (CQRGMF), which is the primary land use planning policy vehicle for the region, has a particular perspective on climate issues which stems from the fact that the region is a significant emitter of greenhouse gases (GHG). It contains a number of production industries including the world's largest alumina refinery and Australia's largest aluminium smelter, Queensland's largest manufacturer of cement, Australia's second largest meat processor and operational plans for the world's largest magnesium metal production facility (2002, p.33) whilst the economy is largely underpinned by coal exports with 42% of Queensland's coal production located in the region. As a result, the plan's focus is on policies to deal with this high per capita emissions scenario without detrimentally impacting on economic prosperity. The majority of policy which explicitly relates to

climate in the plan is concerned with GHG, and it contains little discussion of potential climate impacts or the need for adaptation responses. Section 2.8 (p.30) of the plan, which sets the framework for policy by examining global trends impacting on central Queensland, contains no discussion of risks associated with climate change beyond those associated with the GHG intensive nature of the local economy. The most explicit recognition of the need for climate adaptation notes that policy should '*Recognise and initiate strategies to assist people, landscapes, plants and animals to adapt to climate change and increased vulnerability to weather changes*' (p. 50). This approach is in sharp contrast to South East Queensland Region (SEQRP). Here a key document is the *SEQ Climate Change Management Plan* which informs policy in the *SEQ Regional Plan*.

This document, which was commenced prior to the publication of the *SEQ Regional Plan* (2009a), sets the context for climate change response policy in South East Queensland. It broadly gives equal weight to policy on mitigation of climate change and on adaptation. The focus, in the latter case, is on the development of planning policy which helps communities improve their resilience to natural hazards and oil price rises (p.11). Climate change policy is firmly embedded within broader sustainability policy. The SEQRP categorises rapid onset hazards which include heatwaves and high temperatures, cyclones and severe winds, severe storms and hail storms, riverine flooding and storm tides, bushfires, landslide and coastal erosion. Gradual onset hazards include sea level rise and reduced and highly variable rainfall (p.45). The SEQRP further notes that '*Natural hazards such as flooding, bushfires and storm surge pose a significant risk to communities and infrastructure in SEQ. Climate change is expected to increase the frequency and severity of extreme weather events that cause these natural hazards. In addition to factors such as rising sea levels, natural hazards pose a significant risk to development in SEQ. The United Nations Intergovernmental Panel on Climate Change (IPCC, 2007) has identified SEQ as one of six 'hot spots' in Australia where vulnerability to climate change is likely to be high*' (p.44).

HEAT

Whilst there is no discussion of extreme temperatures or heat waves in the CQRGMF, the *Gladstone Planning Scheme*, which translates the broad policy aims of the CQRGMF into detailed assessment criteria, contains some elements which directly relate to these issues. For example, it contains frequent mention of the need for shade, notably through planting of trees in public places such as car parks (p.4-35) and pedestrian areas (p.4-16). Interviews with Gladstone council officers suggested that increased urban heat island effect from increased residential densities resulting from smaller lot sizes was a cause of concern. However, this issue is not addressed in the Planning Scheme. Also, a suggestion was made that designing curved as opposed to straight streets could facilitate better shade planting but this concept does not appear in formal planning policy. In respect to the Target, the SEQRP contains a general provision to '*establish adaptation strategies to minimise vulnerability to heatwaves and high temperatures*' (p.44). However, the Local Planning Scheme in Moreton Bay has yet to *incorporate* this provision into detailed policy.

DROUGHT

The CQRGMF notes that industry has had significantly harmful effects on water quality in rivers. It also notes that almost all river flows in the region are regulated using dams and weirs in the interests of industrial production. Water supply is seen as critical for urban and industrial development (p.114) and as a major challenge facing the region. In respect to agriculture, the further development of cotton growing, where almost 90% of land under production requires irrigation, and beef production, are critically reliant on the availability of water supplies (p.113). Nevertheless, the discussion is not related to past or future climate and there is no discussion of drought or changing rainfall patterns. In respect to infrastructure provision in new developments,

consideration of rainfall and climatic conditions are assessable items as specified in the *Gladstone Planning Scheme* for the Harbour Islands locality code, but not more generally (p.9-17). More broadly, neither level of planning policy seems to contain policy relating to the desirability of water harvesting apart from situations where reticulated water supply is not possible. However, this aspect is picked up in the Building Code Provisions so may not be seen as relevant to planning policy.

BUSHFIRE THREAT

Whilst they do not explicitly relate these specifically to climate, there are a number of policy statements in the *Gladstone Planning Scheme* which note the desirability of ensuring that new development is sited to minimise risk from bushfire hazard (p.1-8, p. 7-43, p.11-36). Reference is also made to current building standards, notably *Bushfire Prone Areas – Siting and Design of Residential Buildings* and to State Planning Policy 1/03 *Mitigating the Adverse Impacts of Flood, Bushfire & Landslide* (Planning Services, DCILGP). *IS IT* (Department of Infrastructure and Planning 2003). The CQRGMF contains no references to bushfire risk but this is noted as a significant risk in the SEQRP. The Caboolture Planning Scheme translates this concern to bushfire overlays which identify areas of hazard.

HIGH VELOCITY WIND

Despite the potential for tropical cyclones to impact on Gladstone, there is no discussion in the planning policy documents of measures to plan for or deal with such an eventuality. Structural issues relating to building design aimed at coping with high wind loadings is an issue for the BCA which is not covered in planning policy. The only policy in respect to wind relates to air quality issues resulting from poor control of dust from stockpiles or vehicle loads (Sinclair Knight Mertz, 2006 p.11-59, p.11-68). In respect to the Target, the SEQRP notes the need to '*Reduce the risk from natural hazards, including the projected effects of climate change, by establishing adaptation strategies to minimise vulnerability to cyclones and severe winds, and severe storms and hail*' (p.44). Again these provisions have yet to be incorporated into the new Local Planning Scheme.

FLOODING/INTENSE RAINFALL

Neither the CQRGMF nor the Gladstone Planning Scheme note issues arising from intense rainfall. However, in its Natural Hazards section the SEQRP notes the need to '*Reduce the risk from natural hazards, including the projected effects of climate change, by establishing adaptation strategies to minimise vulnerability to heatwaves and high temperatures, reduced and more variable rainfall, cyclones and severe winds, and severe storms and hail*' (p.44). In respect to developing new policy, the target appears to be leading the analogue, but it is not possible to identify existing policy in either analogue or target which addresses intense rainfall as a concern of planning policy.

Flooding is noted in the CQRGMF as a development constraint (p.176) and increasing public awareness of the risk is seen as a strategic action (p.51). Risk of hazard from flooding should be minimised according to the *Gladstone Planning Scheme* (p.1-8). SEQRP notes flooding as a development constraint (p.20, 30) and specifically relates this to the influence of climate change (p.44), noting that '*The flood hazard area should be determined based on a defined flood event, taking into account the effects of climate change on rainfall and storm surges*' (p.137). The use of Water Sensitive Urban Design is recommended as a solution to increased overland flow risk. The recognised need for policy, detailed data in the form of constraint maps and positive policy suggestions such as WSUD, implies that in this case the target is in advance of the analogue in developing planning policy to address flooding.

COASTAL

CQRGMF recognises the need for better public understanding of issues relating to sea level rise in its policy on Coastal Planning and Management by increasing '*business, industry, government and community awareness of the potential impacts of cyclonic events, storm surges, erosion, flooding and rising sea levels on land use planning and development*' (p.53). However, there are no further references to changing sea levels in either of the key policy documents relating to Gladstone. The Curtis Coast Plan notes that 'development should avoid potential for unacceptable risk from coastal hazard' and provides spatial recommendations for locating development. The recently adopted *Wide Bay –Burnett Regional Strategy* (2010a, p.12) contains significant recognition of climate influences on policy with a discussion of the need for revised coastal policies and broader policies to improve community resilience in the face of a changing climate. The SEQRP notes that '*Planning for natural hazards in SEQ will be informed by the projected sea level rise outlined in the Queensland Coastal Plan*' (p.45). Both the CQRGMF and SEQRP contain policies in respect to coastal management which focus heavily on policies designed to avoid disruption to natural ecosystems. Policy in respect of the vulnerability of coastal development to rising sea levels is contained within the *Queensland Coastal Plan* and the advice contained in the guideline document *Mitigating the adverse Effects of Storm Tide Inundation*. In all cases local planning schemes must adhere to the state policy and to any published regional coastal policy. However, the local plans are only now emerging.

SUMMARY

See Tables 13 for a summary of the analysis of land use planning policy and plans for response to climatic factors for Gladstone and Moreton Bay. State wide planning policies ensure that locally relevant issues are addressed in a similar fashion across Queensland. From the review of policy and interview responses, it is clear that there is a good awareness of the need to incorporate climate influences into planning policies, but in many instances this is work that remains to be done in emerging local planning schemes. Gladstone seems to be more focussed on GHG mitigation than adaptation to climate. Moreton Bay, particularly through the medium of the SEQRP, which relates to the whole of the Brisbane metropolitan region, appears to be in advance of Gladstone in defining the issues and developing policy in respect to flooding and coastal related climate issues. Overall therefore, in respect to land use planning, there is little evidence of potential learning from analogue to target; in fact the potential lessons may flow the other way.

Table 13 Analysis of integration of climate factors into land use planning policies, plans and processes for Gladstone and Moreton Bay

Gladstone –Moreton Bay					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Gladstone Gladstone Planning Scheme</p> <ul style="list-style-type: none"> shade, notably through planting of trees in public places such as car parks (p.4-35) and pedestrian areas (p.4-16) 	<p>Gladstone CQRGMF</p> <ul style="list-style-type: none"> water identified as critical issue -for industry and agriculture discussion not related to fluctuating or changing climate 	<p>Gladstone Gladstone Planning Scheme</p> <ul style="list-style-type: none"> notes the desirability of ensuring new development is sited to minimise risk from bushfire hazard (p.1-8, p. 7-43, p.11-36). building standards, notably Bushfire Prone Areas – Siting and Design of Residential Buildings and to State Planning Policy 1/03 Mitigating the Adverse Impacts of Flood, Bushfire & Landslide 	<p>Gladstone <i>No evidence</i></p>	<p>Gladstone CQRGMF</p> <ul style="list-style-type: none"> flooding is noted as development constraint (p.176) increasing public awareness of the risk is seen as strategic action (p.51) <p>Gladstone Planning Scheme</p> <ul style="list-style-type: none"> Risk of hazard from flooding should be minimised (p1-8) 	<p>Gladstone state wide policy framework through Queensland Coastal Plan CQRGMF</p> <ul style="list-style-type: none"> ‘Increase awareness of the potential impacts of cyclonic events, storm surges, erosion, flooding and rising sea levels’(p.53). <p>Curtis Coastal Plan</p> <ul style="list-style-type: none"> Development should avoid potential for unacceptable risk from coastal hazard.
<p>Moreton Bay SEQRP – Natural Hazards (p.44)</p> <ul style="list-style-type: none"> Establish adaptation strategies to minimise vulnerability to heatwaves and high temperatures. 	<p>Moreton Bay SEQRP – Natural Hazards (p.44)</p> <ul style="list-style-type: none"> Establish adaptation strategies to reduced and more variable rainfall, <p>Caboolture Shire Plan</p> <ul style="list-style-type: none"> The adverse effects of naturally occurring and man-made hazards on the natural environment and human communities are minimised. (p19) 	<p>Moreton Bay SEQRP</p> <ul style="list-style-type: none"> noted as a significant risk <p>Caboolture Shire Plan</p> <ul style="list-style-type: none"> translates this concern into bushfire overlays which identify areas of hazard 	<p>Moreton Bay SEQRP – Natural Hazards</p> <ul style="list-style-type: none"> Needs to ‘reduce the risk from natural hazards, including the projected effects of climate change, by establishing adaptation strategies to minimise vulnerability to cyclones and severe winds, and severe storms and hail’ (p.44). 	<p>Moreton Bay SEQRP</p> <ul style="list-style-type: none"> notes flooding as a development constraint (p.20, p. 30) specifically relates to the influence of climate change (p.44) ‘The flood hazard area should be determined based on a defined flood event, taking into account the effects of climate change on rainfall and storm surges’ (p137). The use of Water Sensitive Urban Design as a solution to increased overland flow risk. 	<p>Moreton Bay SEQRP</p> <ul style="list-style-type: none"> Storm surge is noted as an issue to take into account (p.137). <p>Caboolture Shire Plan</p> <ul style="list-style-type: none"> The adverse effects of naturally occurring and man-made hazards on the natural environment and human communities are minimised. (p19).

3.3.6 Infrastructure

Queensland infrastructure policies are generally related to meeting the needs of an increased population and/or servicing the industry sector. The South East Queensland Infrastructure Plan and Program (SEQIPP) (2010b) outlines the Queensland Government's infrastructure priorities to support the South East Queensland Regional Plan (2009a).

Geoscience Australia published a multi-hazard risk assessment for Gladstone (Geoscience Australia 2001) as well as a summary of natural hazards in Southeast Queensland (Geoscience Australia 2001a), and these studies form background to this section.

HEAT

The Gladstone Regional Council (Interview, 24 January 2011) noted a trend towards less public use of town squares, and heat may be a factor. It was also noted that increased heat had also impacted on working conditions in the Boyne Smelters. However, no heat related policies pertaining to infrastructure were in evidence.

Again, in relation to Moreton Bay, no evidence could be found of the influence of heat on infrastructure policies e.g. peak energy demand. Electricity demand in SE Queensland, though, is growing at a higher rate than population growth. Most of this region's power is generated outside the region, primarily due to the location of fuel sources. Electricity is transported to the demand centres within South East Queensland via the high voltage electricity transmission network owned, developed and operated by Powerlink Queensland. Gas infrastructure, similar to electricity, consists of major transmission lines (pipelines) and localised distribution networks (Department of Infrastructure and Planning, 2010b).

The Climate Risk Report (Climate Risk Pty Ltd, 2009) for Moreton Bay acknowledges that extreme and increased average temperatures also place a considerable strain on the built environment. For roads, increased temperatures during summer can prematurely crack the road surface and damage its waterproofing. Again, this was not reflected in policies.

DROUGHT

Learning from increased incidence of drought conditions is apparent in the Gladstone -Moreton Bay pairing. Whilst at the time the research was being conducted (January 2011) much of Queensland was inundated by massive floods, Gladstone had suffered drought conditions over the previous few years. The rapid pace of economic development in the area (80% of Gladstone's water is consumed by industry) had begun to place extreme demands on water resources.

The Gladstone Area Water Board (GAWB) undertakes a regional approach to water supply planning and, through partnership with industry, local government and others, has developed the Central Queensland Water Supply Strategy (Gladstone Area Water Board, 2006). The need for a new approach to regional water supply planning arose when it became evident that serious water shortages could hamper the surge of growth and progress.

Whilst water availability has fluctuated from drought (up until 2003) to flood (2010-2011), there is an overall recognition of water scarcity. The GAWB developed a Drought Management Plan in 2007 after a series of long-term droughts in the 60s, 80s and 90s culminating in 1997-2003. The 1950s and 1970s experienced relatively high rainfall (Gladstone Area Water Board, 2007).

The board currently sources all of the water delivered to municipal and industrial customers from the Awoonga Dam. Raising the dam to 40m Australian Height Datum (AHD) was completed in

June 2002, although the dam overflowed at the end of 2010. The GAWB considered various water supply options, such as raising the Awoonga Dam 4.6m above the spillway, or constructing a 120km pipeline from the Fitzroy River. Since local sources appeared inadequate to supply existing and planned industrial developments, it has been decided that they will construct a pipeline at a cost of \$20m to transfer water from the Fitzroy River Catchment to Gladstone to service the industry requirements. It was admitted that this pipeline would not be in continuous use, but would only be called upon in situations of extreme water shortage. This is supplemented by the Agnes Water and Seventeen Seventy Integrated Water Project, involving a desalination plant and water recycling.

Thus, the mechanisms proposed to meet the new challenges include new pipelines to link key water infrastructure, within and outside the region, to areas of greatest need. In this way, a regional water grid will be established, forming a first step towards a state wide water grid. Key water infrastructure, which would form part of a state wide grid, is associated with the Central Queensland Regional Water Supply Strategy.

Moving to the SE Queensland and Moreton Bay region, Seqwater takes an integrated approach to the management of natural and built water supply assets in the region, as well as positively influencing the management of wider catchment resources. It recognises that catchments are complex systems, with their productivity being subject to changes in weather patterns, economic demands and other factors. For catchment-sourced water in particular, climate factors are recognised as undermining current assumptions about the stability of the water-energy co-dependency, with potentially significant economic and political implications. *The Seqwater 2011-12 to 2014-15 Strategic Plan (2010)* acknowledges that, despite the end of the recent drought, there is ongoing community concern about long-term water security. In response to the drought, it initiated water supply emergency projects, including the raising of the Hinze Dam and interconnection of the Ewen Maddock Advanced Water Treatment Plant.

The \$6.9 billion Queensland Government's South East Queensland Water Grid is reported to be the largest urban drought response in Australia, securing the region's water supply now and for the future. The water grid is a network of connected water supplies, storages and pipelines allowing water to be transported from areas of water surplus to areas facing a shortfall. Completed projects include: Western Corridor Recycled Water Project; Southern Regional Water Pipeline; construction of Wyaralong Dam is expected to be completed by December 2011; the Wyaralong water treatment plant will be constructed in stages to supply water into the South East Queensland Water Grid (Department of Employment, Economic Development and Innovation, 2010).

Locally, the Caboolture Shire Plan (now part of Moreton Bay Regional Council) includes provisions that contribute to the overall improvement of water use within the district, including rainwater tanks and dual reticulation. Similarly, the draft *Pine Rivers Shire Local Growth Management Strategy (2007)* exemplifies how MBRC is managing the provision of water infrastructure. To the extent required and facilitated following the water industry reforms, the council will meet its obligations to provide a water supply and sewerage service to existing and new urban areas. Development in the greenfield areas of the Shire will implement the principles of the Integrated Urban Water Management Strategy (IUWMS) adopted by council in 2006.

BUSHFIRE THREAT

In relation to bushfire requirements for infrastructure, there was no discernible difference between Gladstone Moreton Bay policies and responses.

Gladstone City Council and Calliope Shire Council, amalgamated in 2008 under Gladstone Regional Council, have a Bushfire Risk Assessment and Management Plan. This is reflected in the Bushfire Management Plan (Australia Pacific LNG and WorleyParsons, 2010) prepared for

the new Australia Pacific LNG facility located on Curtis Island – a designated ‘Bushfire Hazard Area’ (medium risk).

An interview (24 January 2011) with the Gladstone Regional Council highlighted an increasing awareness of bushfire risk, especially given the expansion of the township into bushland areas. Within MBRC, the Pine Rivers Planning Scheme Policy PSP15 addresses ‘*Demonstrating Compliance with the Bushfire Hazard Area Overlay Code*’ (Moreton Bay Regional Council, 2009). This results from a Bushfire Management Strategy Study prepared by Landmarc Ltd for Pine Rivers (2003). Significantly, the report notes that ‘*the wellbeing and safety of the community is also dependant on a range of lifeline infrastructure networks*’. These include the road network; the rail network; power reticulation services; water reticulation services; sewerage reticulation services; telecommunications services and logistic support facilities (e.g. fuel and food supply). Whilst bushfires may pose a direct threat only to the above-ground components of these systems, most of them are largely dependent on power supply for their operation and to a lesser extent on the road network to provide access for repair and recovery crews. Disruption to the power supply and dislocation of the road network will have significant knock-on effects to all lifeline services.

HIGH VELOCITY WIND

It is noteworthy that cyclones are not covered by the State Planning Policy *SPP 1/03 on ‘Mitigating the Adverse Impacts of Flood, Bushfire and Landslide’*, although the risks associated with tropical cyclones was highlighted by Geoscience Australia in its reports covering Gladstone (2001) and Southeast Queensland (2001a) The Australia and NZ Standard for Wind AS 1170.2: 2011 is relevant.

However, there is evidence that cyclone risk is being considered, at least by the Queensland Department of Transport and Main Roads. Commenting on the Environmental Impact Statement (EIS) for the Santos Liquid Natural Gas (LNG) project at Gladstone, the Department asked that risks associated with cyclonic weather should be appropriately addressed. Santos responded that it had identified cyclones as a natural hazard in the EIS and, although not among the top project risks, was incorporating this into the LNG facility design. Examples included structural design and stormwater management.

In relation to the Moreton Bay region, there is some recognition of the risks associated with high winds. For example, although the area of the Narangba Industrial Estate (NIE) had a moderate wind risk (The Institute for International Development, 2007), concern was expressed that some of the buildings, especially older structures, may not have been designed to withstand the full force of a category 5 cyclone. Should extreme weather events damage the noxious industries in the region, there is potential for impacts on health and environment. Furthermore, the NIE is an important economic provider for the Moreton Bay region and employs hundreds of people (Climate Risk Pty. Ltd. 2009).

FLOODING/INTENSE RAINFALL

The Queensland Urban Drainage Manual (2007), which deals primarily with the hydrology/hydraulics of drainage systems, aims to provide local governments and storm water professionals with a standardised approach to planning and design of urban storm water drainage. The manual has traditionally dealt mainly with passing run-off through and away from urbanised areas to meet flood mitigation, public safety and convenience objectives. However, as the impact of storm water on the environment and the need to manage it as an integral part of the urban water cycle are now widely recognised, the latest edition provides guidance in addressing these issues when planning and designing the system. The manual also highlights the comprehensive planning approach necessary to achieve best practice.

The impact of intense rainfall and flooding on infrastructure, and hence on economic performance, is illustrated by the impact of the 2010/2011 floods in the Gladstone region, when coal production was cut by 40 per cent due to mines being flooded and rail infrastructure in the Gladstone hinterland being washed away



Figure 1 Rail damage January 2011 in Comet Region, (photo courtesy of Gladstone Regional Council).

The costs to the coal industry were estimated to be around \$2 billion, plus an indirect cost to the Gladstone, Queensland and national economy. There was also a risk that the power station serving Gladstone itself would need to be shut down due to dwindling coal supplies (*The Observer*, 2011).

There is evidence that infrastructure projects in the Gladstone area are addressing the policy requirements of the aforementioned State Planning Policy SPP 1/03 on mitigating the adverse impacts of flood, bushfire and landslide. For example, the Gladstone-Fitzroy River Pipeline Project (Gladstone Area Water Board) not only addresses the intake from the Fitzroy River in terms of the river flood level, but also the risks associated with the pipeline traversing flood prone area through undergrounding the pipeline.

The \$1.65 million Tigalee Creek flood mitigation project near Gladstone aims to reduce the incidence of flooding (and erosion) along the embankments of Tigalee Creek at Sun Valley during heavy rain events. This project involves construction of a Dry Bed Stormwater Retarding Basin, at the same time improving the amenity of the park (Gladstone Regional Council 2010d).

Extensive flood mitigation studies have been undertaken in the Moreton Bay Region. The MBRC has responsibility for overall floodplain planning and management of the Pine River system. Flooding along the various waterways and throughout the floodplain represents a major

constraint to both existing and future development. In addition, flooding represents a critical aspect in the overall disaster risk management functions undertaken by council. This is especially the case for the Pine River system as this represents the largest waterway system across council and has considerable flooding implications. Specifically, the Lower Pine Rivers Flood Study (WorleyParsons, 2009) and associated outputs forms the basis on which council can effectively and efficiently control future development and urban consolidation throughout the Pine River system; proactively manage as well as coordinate future floodplain management and disaster risk management functions; and facilitate in the preparation of a flood warning system for the catchment, including formulating an emergency management response plan.

The former Pine Rivers Shire Council commissioned a Griffin Area Regional Flood Study in 2005. Owing to the existing development pressure within the catchment and the balance that needs to be maintained with regard to public safety and egress in addition to other competing factors including environmental aspects associated with the lower tidal wetland system, it was recommended that council should develop a Strategic Master Drainage Plan for the Griffin Area. This plan could be used to control development in the catchment in a planned manner without adversely compromising other aspects including storm surge and environmental and public safety. It was also noted that owing to the significant tidal ingress which occurs in the Griffin catchment, the consideration and adoption of an applicable storm surge level for Ilays Inlet and the Pine River system will be critical for future development control. The adoption of a higher storm surge level than the 1.92m AHD level applied in this study would result in higher flood levels throughout the area and consequently less developable areas available within the catchment. This aspect would need to be prescriptively addressed through the re-analysis of the hydraulic model in order to determine the resulting impact on flood levels, should a higher storm surge level be adopted. It was recommended that council re-assess flooding in the Griffin Catchment should a higher storm surge level be adopted.

The council's Policy *PSP17 Demonstrating Compliance with the Major Flood Events Overlay Code* (Moreton Bay Regional Council, 2008a) is of special relevance. Based on such flood studies prepared by the former Caboolture, Redcliffe and Pine Rivers Councils, the MBRC has compiled a series of maps, available for free download, showing areas of potential inundation of the ground surface during a 1 in 100 year flood. These maps will be progressively upgraded as new data emerges from the Regional Floodplain Database Project.

COASTAL

Coastal erosion was identified as a significant problem in both the Agnes Water area of Gladstone, also in the Redcliffe area of Moreton Bay, highlighting the need for improved dune management. The width of the erosion-prone area for Agnes Water beach is 110m measured landward from the toe of the frontal dune. Recent events at Agnes Water, such as clearing of frontal dune vegetation for improved ocean views from adjacent development, replacement of coastal caravan parks with intensive unit developments, and uncontrolled pedestrian access to the beach, has highlighted the need for improved dune management. Agnes Water is typical of most small Queensland coastal towns and is experiencing increased tourism and urban development. Over many years, the EPA has pursued its preferred approach to management of the erosion prone area, through land surrender. This ensures that the erosion prone area is secured as a reserve under the trusteeship of local government and allows natural processes of erosion and accretion to continue without threatening property (Walsh and Stewardson, 2002).

By contrast, within the Moreton Bay area, the Redcliffe Shoreline Erosion Management Plan Report (2009) recommended implementation of costly engineering capital works (i.e. implementation/upgrade of shoreline structures and initial beach nourishment) that would cost in the order of \$9 million, This would need to be followed by an ongoing maintenance expenditure of about \$270,000 per year for beach nourishment and sand recycling operations, plus about \$270,000 per year for ongoing maintenance and repair of the various existing and proposed shoreline protection structures. In addition, there should be a minimum provision of about

\$60,000 per year for beach monitoring, dune management, inspections and project management. This provides an indication of the substantial expenditure that councils face for coastal protection infrastructure.

Houghton Bridge, Redcliffe, one of the few in Australia to be affected by storm surge, has been redesigned and constructed to withstand a 1 in 2000 year storm event (Climate Risk Pty Ltd, 2009).

SUMMARY

See Table 14 for a summary of the analysis of infrastructure policy and plans for response to climatic factors for Gladstone and Moreton Bay. There appeared to be few differences between the approaches of both communities, and hence little opportunity for learning from the analogue (Gladstone). In terms of the ongoing implementation of water supply policy in response to historic droughts the analogue, Gladstone appears to be forging ahead, but the actual policy solutions are not substantially different from those in the target community of Moreton Bay and SE Queensland more widely. Perhaps the only significant contrast is the recognition by the analogue that construction of the Fitzroy River pipeline is a contingency to deal with extremes, and not an infrastructure component that will be in continuous use.

Potential analogue/target contrasts are also represented by the 'softer' approach to addressing coastal erosion displayed in Agnes Water in the analogue, which compares with the costly engineering solutions being adopted in Redcliffe in the target area.

Table 14 Analysis of integration of climate factors into infrastructure policies, plans and processes for Gladstone and Moreton Bay

Gladstone –Moreton Bay					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Gladstone</p> <ul style="list-style-type: none"> GRC noted (Interview 24 January 2011) reduced use of public spaces, heat may be a factor Increased heat had impacted on working conditions in Boyne Smelters. 	<p>Gladstone</p> <p>The Central Queensland Regional Water Supply Strategy</p> <ul style="list-style-type: none"> was a response to severe drought in the region regional water grid being established 1st step of state wide grid <p>Gladstone Area Water Board's Strategic Water Plan 2004</p> <ul style="list-style-type: none"> considered possible options, i.e. dams /weirs; water management for supplying water to area Gladstone – Fitzroy Pipeline identified as best option <p>Agnes Water - Seventeen Seventy Integrated Water Project</p> <ul style="list-style-type: none"> desalination plant water recycling 	<p>Gladstone</p> <p>Bushfire Risk Assessment & Management Plan</p> <ul style="list-style-type: none"> increasing awareness of risk due to expansion of township into bushland areas (Interview Gladstone Regional Council 24 Jan 2011) 	<p>Gladstone</p> <p>AS1170.2 standards for wind – region C</p> <ul style="list-style-type: none"> Queensland Dept of Transport & Main Roads highlighted risks of high winds to Santos LNG project 	<p>Gladstone</p> <ul style="list-style-type: none"> December 2010 - Awoonga Dam Wall overflows for first time. <p>Queensland Urban Drainage Manual 2007</p> <ul style="list-style-type: none"> guiding LGs with stormwater design and management Flood indicators provide information on the depth of the water at crossings and low-lying areas but they do not show the strength of the current, which is often under-estimated by drivers - Miriam Vale area, in particular. <p>Auckland Creek Flood Study Report 2006</p> <ul style="list-style-type: none"> led to the Tigalee Creek Project, with a water retardation basin created (recently completed) 	<p>Gladstone</p> <ul style="list-style-type: none"> harbour protected against storm tides <p>Agnes Water:</p> <ul style="list-style-type: none"> EPA 'soft' approaches to management of erosion – erosion prone areas secured as reserve, allows natural processes without threatening property and assets (see Walsh & Stewardson, 2002).
<p>Moreton Bay</p> <p>No evidence</p>	<p>Moreton Bay</p> <p>The SEQ Infrastructure Plan and Program 2005-2026</p> <ul style="list-style-type: none"> SE Queensland water grid. SeqWater takes integrated approach to management of natural and built water supply assets, recognises catchments are complex systems 	<p>Moreton Bay</p> <p>No evidence</p>	<p>Moreton Bay</p> <p>AS1170.2 standards for wind – region B</p> <ul style="list-style-type: none"> Some recognition of risk of high wind e.g. possible damage to old structures in Narangba Industrial Estate could lead to spread of pollution. 	<p>Moreton Bay</p> <p>Queensland Urban Drainage Manual 2007</p> <ul style="list-style-type: none"> guiding LGs with stormwater design and management <p>The Healthy Waterways Water Sensitive Urban Design – Technical Design Guidelines for South East Queensland</p> <p>Various flood mitigation reports/studies undertaken since early 1990s.</p>	<p>Moreton Bay</p> <p>Redcliffe Shoreline Erosion Management Report (2009)</p> <ul style="list-style-type: none"> recommended costly engineering capital works compare with 'softer' Agnes Water approach (above) Houghton Bridge Redcliffe, one of few in Australia to be affected by storm surge, redesigned and constructed to withstand 1 in 2000 yr storm event (Climate Risk Pty. Ltd. P.63)

3.3.7 Housing/Building

The Queensland Development Code provides a single document in which building standards specific to the state are consolidated. This is based on the requirements of the BCA and includes aspects outside of the scope of the national code. As part of a greener buildings initiative, the Queensland Government has introduced new sustainable housing laws.

HEAT

The effect of heat waves on the wellbeing of building occupants is already a problem that is likely to become more significant. Granger (2005) has reported that more than 34 deaths and nearly 2000 admissions to hospital have been caused by heatwave events in subtropical South-East Queensland since the year 2000. A study of the use of air-conditioners in South-East Queensland mentions the possible policy response of mandatory inclusion of an air-conditioning unit in at least one room in every house to create a refuge during heatwave events (Aitken and Losee, 2006). This concept was incorporated in a recommendation by Losee *et al.* (2007) to the Brisbane City Council and is also reflected in overseas experience in retirement homes in France (Kovats and Ebi, 2006).

The mean maximum temperature for Gladstone is outside the comfort zone for a large proportion of the year and the relative humidity is generally above the 40% – 60% level which means that the majority of residents adopt some cooling of their houses. Gladstone and Moreton Bay are within the same climate zone 2 which eliminates any differences arising from the energy efficiency regulations within the deemed-to-satisfy provisions of the BCA for buildings. However, for alternative energy efficiency solutions for houses using Nationwide House Energy Rating Scheme (NatHERS) software, Gladstone (TMY dataset 36) and Brisbane (TMY dataset 10 which includes the Moreton Bay council area) have their own weather files enabling greater discrimination in current climate conditions between the analogue and target. In addition to using different climate datasets, the maximum allowable energy load for heating and cooling for 6-star performance is marginally higher for houses in the location of the analogue to allow for the less moderate climate. Buildings other than housing e.g. hotels, offices, shops, medical facilities and education buildings, as described in Volume 1 of the BCA, can also comply with the energy efficiency requirements via the alternative solution route using approved building energy analysis software with local climate data.

DROUGHT

In Agnes Water, within the Gladstone Regional Council, local government has stipulated that new dwellings are required to have tanks with a minimum capacity of 22,500 litres installed. This is significantly more than the 5,000 litres minimum required under the State Development Code and which applies in Moreton Bay. See Box 4 for more information about the policies to ensure water security in the Gladstone Regional Council area.

Box 3 Residential Rainwater Tanks in Queensland

Box 4. Residential rainwater tanks in Queensland

The Queensland Government's ClimateSmart 2050 strategy is aimed at addressing the various aspects of climate change including water supply. This is supported by the Queensland Development Code (QDC) Part MP 4.2 which deals with water security by implementing mandatory targets for water savings for all new class 1 buildings (houses, townhouses and terrace houses). These targets can be achieved in a number of ways, including household rainwater tanks, communal rainwater tanks, greywater treatment plants, dual reticulation and stormwater reuse. New houses in reticulated water areas must have rainwater tanks with a minimum capacity of 5000 litres plumbed to toilet cisterns, washing machines and an external tap. This requirement is statewide including the target of Moreton Bay.

Elsewhere, the minimum capacity has been increased at a local government level and this is the case for Agnes Water within the Miriam Vale Shire to the south of the Gladstone analogue and within the Gladstone Regional Council area. For some time in Agnes Water, minimum capacity water tanks of 2,500 litres have been required. For other areas, sustainable communities have been encouraged by introducing water savings targets for dwellings where the plumbing is directly linked to a pressurised and reticulated town water supply. This allows for smaller tanks than are currently mandated in Agnes Water. The minimum specification is 45 litres for every 1m² of roof area or 10,000 litres whichever is the greater. Plumbing should allow for the stored rainwater to be used for flushing toilets, washing machines and cold water taps. This provides an example of current water saving specifications for new houses being more stringent for the analogue due to differences in climate.



Rainwater tanks in the analogue area of Queensland are important for water security (Image Source: <http://www.environment.gov.au/water/programs/nrgi/index.html>)

BUSHFIRE THREAT

Queensland Fire and Rescue Service (QFRS) is the designated Threat Specific Agency for bushfire under the State Disaster Management Arrangements (Part. 2.1-1 p. 177). Queensland Health Fact Sheets (based on similar ones from Victoria) provide information on Bushfires and Water Tanks which advises action such as installing a first flush diverter between the roof and the tank to prevent ash and other debris contaminating the water. These are available from most hardware stores and suppliers of rainwater tanks.

HIGH VELOCITY WIND

AS/NZS 1170.2:2011 Structural design actions Part 2: Wind actions referred to in the BCA places Gladstone in Region C and Moreton Bay in the less severe region B. The current southern limit of Region C according to AS/NZS 1170.2:2011 is currently at the latitude of Bundaberg located between the analogue and the target. This is a current difference which can be considered as an indicator for possible future changes for the target.

The recent publication of this standard (March 2011) indicates the incorporation of research and experiences from severe wind events in Australia and New Zealand. The Joint Committee overseeing this standard is currently considering possible amendments following very recent severe wind events (e.g. tropical cyclone Yasi – February 2011) indicating that adjustment for

climate change has already begun. This may have implications for existing buildings constructed before recent or future amendments were made.

FLOODING/INTENSE RAINFALL

Five minute rainfall intensities at 20 year and 100 year recurrence intervals for Brisbane that are provided in Volume 2 Section 3.5 Roof and Wall Cladding are 251 mm/hr and 333 mm/hr, respectively. Although specific equivalents are given for Gladstone, figures for Rockhampton and Bundaberg indicate intensities of rainfall which are not significantly different to Brisbane.

The local council in the Moreton Bay area has compiled a series of maps, available for free download, showing areas of potential inundation of the ground surface during a '1 in 100 year' flood. These maps are based on flood studies prepared by the former Caboolture, Redcliffe and Pine Rivers Councils.

COASTAL

Within the Gladstone Regional Council, the Curtis Coastal Plan stipulates building lines which occur within coastal management districts and define areas that require special development controls and management practices. The EPA is involved in assessing building works in areas seaward of a coastal building line.

SUMMARY

See Table 15 for a summary of the analysis of housing and building policy and plans for response to climatic factors for Gladstone and Moreton Bay. Gladstone and Moreton Bay are in the same BCA climate zone and the requirements for the deemed-to-satisfy requirements for energy efficiency are similar. However, for alternative solutions for energy efficiency in house design using NatHERS software, both Gladstone and Brisbane (which includes the Moreton Bay council area) have their own weather data sets. There are differences in building design between Gladstone and Moreton Bay with respect to high velocity winds. These current differences in the BCA provide tangible knowledge for targets from the experience of the analogues.

Table 15 Analysis of integration of climate factors into housing and building policies, plans and processes for Gladstone and Moreton Bay

Gladstone –Moreton Bay					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Gladstone BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> similar deemed-to-satisfy provisions for energy efficiency but the alternative solutions route via thermal simulation software uses local meteorological datasets 	<p>Gladstone State Development Code</p> <ul style="list-style-type: none"> requires 5,000 litre rainwater tanks for dwellings <p>In Gladstone Regional area</p> <ul style="list-style-type: none"> Miriam Vale Shire requires 10,000 litres and within this shire, Agnes Water requires 22,500 litres. 	<p>Gladstone</p> <ul style="list-style-type: none"> BCA reference to construction of buildings in bushfire prone areas. Queensland Health Fact Sheets advise on bushfires and water tanks. 	<p>Gladstone</p> <ul style="list-style-type: none"> BCA refers to AS/NZS 1170.2 with Gladstone in Region C. 	<p>Gladstone No evidence</p>	<p>Gladstone No evidence</p>
<p>Moreton Bay BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> similar deemed –to-satisfy provisions for energy efficiency but the alternative solutions route via thermal simulation software uses local meteorological datasets. 	<p>Moreton Bay</p> <ul style="list-style-type: none"> State Development Code requires 5,000 litre rainwater tanks for dwellings. 	<p>Moreton Bay</p> <ul style="list-style-type: none"> BCA reference to construction of buildings in bushfire prone areas. Queensland Health Fact Sheet advises on bushfires and water tanks. 	<p>Moreton Bay</p> <ul style="list-style-type: none"> BCA refers to AS/NZS 1170.2 with Gladstone in Region B. 	<p>Moreton Bay</p> <ul style="list-style-type: none"> Council provides information about flooding in the form of a property-specific report describing the degree of flooding that may occur due to rivers, creeks and tidal areas within the region. 	<p>Moreton Bay No evidence</p>

3.2.4 Health services

In Queensland, the *Health Services Act 1991* defines a health service as a service for maintaining, improving or restoring people's health and wellbeing. The health services may be provided at a hospital, nursing home, community health facility or other place; and include services for public health – the prevention and control of disease or sickness; or the prevention of injury; or the protection and promotion of health. A health service also includes any administrative or other support service directly related to a health service, such as a catering or laundry service provided at a hospital. Area Health Services Plans guide investment for future health services and programs for a local population.

Health services in the GRC analogue area include: a hospital, community health service, oral health service, and a mental health service with a primary health care service located in the Boyne Valley in the southern part of GRC's area. The Gladstone Hospital provides health services including emergency, outpatients, general medicine and surgery (including day surgery), basic orthopaedics, obstetrics and gynaecology, medical imaging, pharmacy, pathology and central sterilising (Gladstone Health Community Council 2010). While air quality has been an issue for the Gladstone region, potential risks are actually managed through state government agencies. The provision of reticulated water, however, is a direct responsibility of GRC which has established the Gladstone Area Water Board, whose prime objective is the provision of safe and reliable supplies at an acceptable cost to the community. In the MBRC target community, Queensland Department of Health (QH) operates the Caboolture Community Health Centre, which provides a range of services for people living in the suburbs north of Brisbane. Its services include: Healthier Children and Families; School Indigenous Immunisation Program; School Based Youth Health; Children's Therapy Services; Aged Care Assessment; Primary Health (includes occupational therapy, nursing, physiotherapy, social work, podiatry); Diabetes Service; Alcohol, Tobacco and other Drug Services; Needle and Syringe Program; Home and Community Care Services; Intake and Referral Services; Sexual Assault Service; Wound Care and a Continence Advisory Service.

Under the *Queensland Disaster Management Act 2003*, local governments have the responsibility to plan and prepare for disasters, to coordinate immediate responses in their event and to coordinate recovery operations. GRC has a Local Disaster Management Plan (LDMP), a Local Disaster Management Group and Local Government Disaster Coordination Centre. The LDMP (Gladstone Regional Council 2010e) identifies events that are likely to happen in each area, the strategies, priorities, and how operations and activities to manage the disaster will be coordinated. The GRC *Strategic Direction for Disaster Management* noted that credible natural disasters for the area were: cyclones (wind, flood and storm surge); floods; severe storms (non-cyclonic); bushfires; earthquakes including tsunami impacts and landslides. The emergencies relevant to the area that MBRC list include: bushfires; cyclone and storm surges; floods; heatwaves and severe storms. Local response organisations include councils, police, and regional State Emergency Service organisations.

HEAT

In the analogue community of Gladstone, the LDMP identifies heat wave as a low risk event. At the workshop on 18 May 2011, Sotiris commented that heat and heatwaves were not of current concern to GRC or its community. However, no data has been made available by Queensland Health to check the incidence of heat related illness presenting to the Gladstone Hospital or local health services in the area.

In contrast to GRC, the MBRC considers weather where the temperature is in the range 37°C to 42°C to be excessive heat and lists heatwaves as an emergency. It defines heatwave as 'High

temperature and high humidity over three or more days'. The MBRC provides advice about recognising signs of heat related illness; and how to prevent heat related illness. Advice about heatwaves is provided on the council's internet site and via printed brochures. In respect to heat and heatwaves, the target community appears more proactive in providing information to residents about the potential health impacts of heat and how to prevent heat related illness.

In the Gladstone analogue community, the presence of marine stingers and Box Jellyfish during summer months requires advice to the public to avoid contact with these creatures and thereby prevent risk to health and increased demand for health services during the summer season. In the MBRC target community, while stingers and Box Jellyfish are not present during summer at this time, increased marine water temperatures during summer, together with favourable light conditions and elevated nutrients leads to rapid growth or blooms of *Lyngbya*, a blue green algae or cyanobacteria. Hence MBRC also notifies the public of the potential health risks through activating warning signs in affected coastal locations. While the biological hazards occurring in summer are different, both communities respond to these hazards in similar manners to prevent increased demand for health services. The question remains as to whether the difference in hazard in the summer season is a factor of differing climate alone or the result of a combination of factors such as the presence of nutrients for *Lyngbya*.

In respect to heat and heatwaves, the target community is more proactive in providing information to prevent heat related health effects which would place demand on health services.

DROUGHT

The main impact of drought that was identified in the GRC analogue community was the impact of blue green algae (BGA) contamination of water sources, which relates mainly to water supply. The Gladstone Area Water Board (2009) has a BGA Action Plan based on Department of Natural Resources and Water (DNRW) guidelines, the Australian Drinking Water guidelines and on advice from BGA experts. The MBRC target community had not identified any impact of drought on health services.

BUSHFIRE THREAT

Both the GRC analogue community and the MBRC target community have identified bushfire as a possible event. The Queensland Fire and Rescue Service (QFRS) is the designated Threat Specific Agency for bushfire under the state's Disaster Management Arrangements. Fact sheets have been prepared by QH and are based on information and advice from Victoria. Bushfires have occurred in the Gladstone area as evidenced by the Clean & Healthy Air for Gladstone Project noting poor air quality associated with grass/bushfires close to the air monitoring station. 'Specific Planning Arrangements' for bushfire threat have been developed for the GRC analogue. The MBRC target community has designated Neighbourhood Safer Places (NSP) within its area. These are local open spaces or buildings where people may gather to seek shelter from a bushfire, although the MBRC states this action is only as a very last resort. The MBRC refers residents to information such as *Prepare.Act.Survive* brochure (Queensland Government Rural Fire Service n.d.). However, in the Mount Nebo area of the analogue community, a warning system has been established that explains the three levels of warning of which residents are to be aware in the event of a bushfire in the area. The state wide focus of the QFRS and the Rural Fire Service operating at the regional and local level where bushfire may be expected to occur, results in few differences in action noted between the analogue and target communities that might be specifically relate to differences in climate.

HIGH VELOCITY WIND

The Bureau of Meteorology (BoM) issues a Cyclone Watch when gales or stronger winds associated with a cyclone are expected to hit within 48 hours, but not within 24 hours. BoM issue a Cyclone Warning when gales or stronger winds are expected to hit within 24 hours.

QH fact sheets provide advice on action to be taken to ensure food safety when cyclones and storms hit, particularly as power failures may affect refrigeration of food rendering it unsafe to eat. Other QH fact sheets developed in response to tropical cyclone Yasi, address advice about drugs and poisons, particularly advice for the public, health practitioners and businesses affected. Advice to professionals about the return of unwanted medicines (RUM) resulted in a RUM project which provides approved containers for the collection and disposal of medicines by an appointed waste transport agent with larger quantities of medicines able to be collected by waste management services.

Cyclones have occurred in the analogue community of Gladstone (see Figure 2). On 2-3 March, 1949, 87 knot wind gusts at Rockhampton and Gladstone resulted in 1500 severely damaged houses, causing damage and flooding in 15 towns and resulting in 7 deaths (Bureau of Meteorology 2011c). The GRC target community has developed Multilingual Natural Disaster Fact Sheets for cyclone action (Gladstone Regional Council 2011).

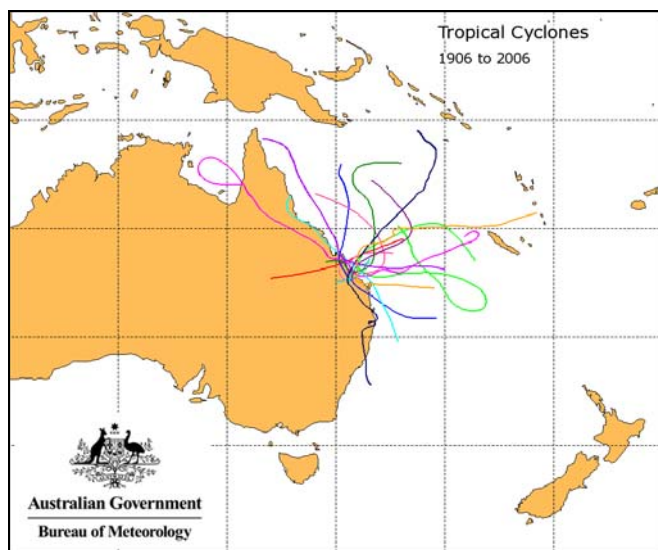


Figure 2 Tropical cyclones crossing within 100km of Gladstone 1906 to 2006 (Source: Bureau of Meteorology 2011b)

In the target community, MBRC lists cyclones and severe storms as emergencies. Cyclones have been recorded in the area (see Figure 3). One example was cyclone Dora, which crossed the coast at Redcliffe on 17 February, 1971 caused widespread structural damage, some flooding and brought down trees and powerlines (Bureau of Meteorology 2011c), although no deaths were recorded. The MBRC analogue community distributes a 'Storm safe' brochure (Moreton Bay Regional Council, DoTARS and Queensland Government Emergency Management Queensland n.d.) which provides advice on how to prepare for storms, such as preparing a family emergency plan; preparing home prior to cyclone season (by November each

year) and developing an emergency kit to take if evacuating. The brochure provides information about contacts in each area. The local radio station (ourbribie.fm) also provides an online summary of key contacts and information on how to prepare for a cyclone and promotes the brochure *Preparing for Cyclones* (Emergency Management Queensland, n.d.).

Comparing the two communities, the focus of emergency management from the state level is similar, and the threat of cyclone and high velocity winds on health has resulted in a similar response in health services, thus differences are not evident.

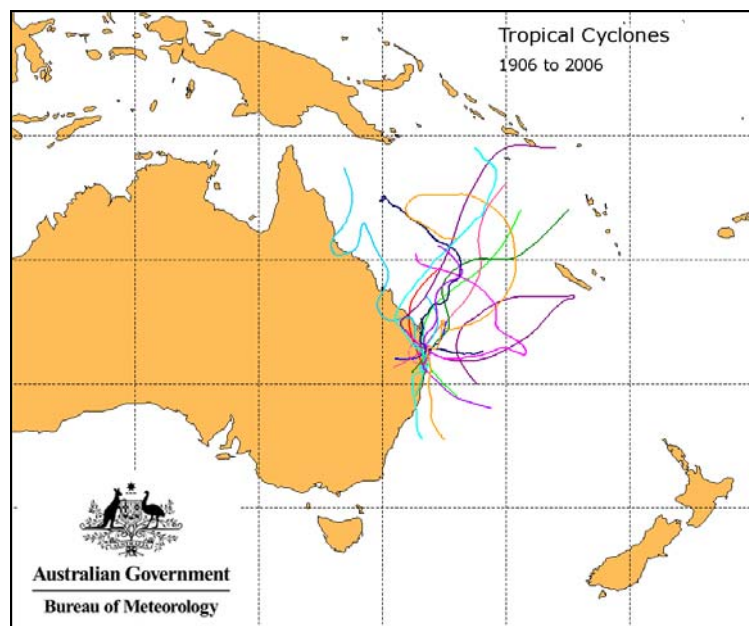


Figure 3 Cyclones crossing within 100km of Brisbane – 1906 to 2006 (Source: Bureau of Meteorology 2011b)

FLOODING/INTENSE RAINFALL

Health services related to flooding and intense rainfall focus on prevention of injury or disease as a result of weather events which may be associated with the prevailing climate of each area, although topographic features are also likely to be important. In each community there is advice provided by QH in the form of fact sheets. QH advise that local councils will issue appropriate advice about the need to take precautions before drinking water in each area. Local health services may also be required to address access to essential medicines due to isolation, financial hardship or lost prescriptions and health care cards. QH have addressed the emergency relocation of approved pharmacies affected by floodwaters. Potential issues also arise due to growth of moulds after floods, resulting in QH developing a fact sheet addressing this factor.

In the GRC analogue community, the Gladstone LDMP identifies severe storms as high risk. The *Gladstone Region Social Infrastructure Strategic Plan* (Gladstone Regional Council 2009) has identified a need for state government inter-departmental consideration of the issue of access between Gladstone and Rockhampton and its effect, on access to regional health services in Rockhampton, including higher order and specialist health services. During the Queensland floods in January 2011, Rockhampton was cut off from all road, rail and air access resulting in temporary health services being set up at the Gladstone Airport. The GRC had developed Multilingual Natural Disaster Fact Sheets for flood action (Gladstone Regional Council 2011b).

Similar to the analogue community, in the target community, MBRC provides advice to residents about preventing potential health impacts of storms and flooding through brochures such as 'Be Storm safe'. MBRC lists floods as an emergency.

Both the analogue and target communities have developed, and implement, programs to control mosquitoes in major breeding sites, and require residents to manage mosquito hazards on their own property. See Figure 4 for an example of the type of advertisements MBRC issue advising residents of the need to be vigilant about mosquitoes after rainfall.



Figure 4 Example of MBRC's advice to residents about mosquitoes (Moreton Bay Regional Council, 2008b)

During the January 2011 floods, two staff members of MBRC target community contracted Melioidosis caused by bacteria (*Burkholderia pseudomalle*) found in soil, mud and water. This disease is of primary health importance in South East Asia and northern Australia. It can be fatal or cause loss of limbs and is brought out during intense rainfall. As a result of the confirmation of the disease, on the 26th of January 2011 several council flood clean-up sites at Centenary Lakes in Caboolture were closed down (Moreton Bay Regional Council, 2011b). The need to provide health services to address this disease in the analogue community had not been noted, although QH were not able to provide statistics to enable a review of hospital admissions in the analogue community.

While there are some minor differences in emergency services response to flooding to prevent health impacts at the local level, the approaches appear to be driven from state level policy for local planning and action to prevent health impacts of flooding and intense rainfall and reduce demand on health services.

COASTAL

The GRC LDMP identifies storm tide and tsunami as possible events in the area – and assesses storm tide as a high risk. Two people drowned near the Town of 1770 (near Gladstone) as a result of Cyclone Sose on 8th April 2001. Large seas and high tides, with waves up to 4.8 metres were recorded at Cape Moreton when large easterly swells came into an area usually protected

from the prevailing south-easterly swells (Padgett 2006). During storm surges, local emergency management and response plans are implemented.

The MBRC lists storm surges as an emergency and, during cyclone Dora, waves broke over the road at Clontarf (near Redcliffe) creating a traffic hazard (see Hodges 1971). Brochures such as 'be storm safe' and warning systems are used to advise communities of action to be taken to prevent injury during storm surges.

It may be concluded that the provision of health services related to coastal impacts of weather events is state-driven through emergency management and emergency response at the local level, and differences between the analogue and target communities are not notable in terms of response.

SUMMARY

See Table 17 for a summary of the analysis of health services policy and plans for response to climatic factors for Gladstone and Moreton Bay. In Queensland, health services are driven from a state level with responses to climatic events coordinated by state agencies. As such, the local responses tend to be driven by the state requirements and programs. The lack of concern about health services to address heat in the analogue community may relate to the demographics of the community and requires further research. The absence of data about hospital admissions at the local level limits the ability to make definitive statements about the health service response to particular weather events, and if these may be due to the different climatic factors experienced in each community.

Table 16 Analysis of integration of climate factors into health services policies, plans and processes for Gladstone and Moreton Bay

Gladstone – Moreton Bay					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/Intense rainfall	Coastal
<p>Gladstone Local Disaster Management Plan (LDMP)</p> <ul style="list-style-type: none"> Heat is low risk. 	<p>Gladstone <i>No evidence.</i></p>	<p>Gladstone State level health advice</p> <ul style="list-style-type: none"> seeking refuge from smoke advises about rainwater tanks and bushfires keep 5-day supply medication <p>LDMP</p> <ul style="list-style-type: none"> bushfire as possible event <p>'Specific Planning Arrangements'</p> <ul style="list-style-type: none"> bushfire threat is High Risk <p>Clean & Healthy Air for Gladstone Project</p> <ul style="list-style-type: none"> some poor air quality related to grass/bush fires 	<p>Gladstone LDMP</p> <ul style="list-style-type: none"> Cyclones are extreme risk. <p>Community Disaster Awareness Guide</p>	<p>Gladstone LDMP</p> <ul style="list-style-type: none"> Floods and severe storms are high risk. Council advise residents about safe routes/road closures. <p>Community Disaster Awareness Guided</p> <ul style="list-style-type: none"> Council relies on resident information about local flooding. <p>Gladstone Region Social Infrastructure Strategic Plan 2009 –</p> <ul style="list-style-type: none"> access between Gladstone and Rockhampton - impact on access to higher order and specialist health services during Jan 2011 flood facilities set up at Gladstone Airport 	<p>Gladstone LDMP</p> <ul style="list-style-type: none"> Storm tide and Tsunami are possible events. Storm tides are high risk. <p>Community Disaster Awareness Guide</p>
<p>Moreton Bay MBRC website</p> <ul style="list-style-type: none"> Heat in range 37°C to 42°C is excessive heat provides advice <p>MBRC Brochure – How to stay safe in a heatwave</p> <ul style="list-style-type: none"> advises action to keep cool, if no air-conditioning, use fans and damp towels 	<p>Moreton Bay <i>No evidence.</i></p>	<p>Moreton Bay State level health advice</p> <ul style="list-style-type: none"> seeking refuge from smoke advises about rainwater tanks and bushfires keep 5-day supply medication 	<p>Moreton Bay <i>No evidence</i></p>	<p>Moreton Bay Flood ALERT system</p> <ul style="list-style-type: none"> base station computers located in the Moreton Bay Regional Council office <p>Local response organisations –</p> <ul style="list-style-type: none"> councils, police, and State Emergency Services in the local area. <p>ABC News - 11 Jan 2011</p> <ul style="list-style-type: none"> 'Police have closed the highway. The normally busy road is now a car park with a traffic jam stretching for kilometres. At Mary Street in Caboolture, residents are fleeing their flooding homes. Some are leaving with nothing more than they can carry - flood waters are rising so fast they cannot do anything else.' <p>Council's regionally based mosquito management program</p> <ul style="list-style-type: none"> aerial (helicopters) and ground treatments spray biological control products - focused on saltmarsh areas within 3-4 days after rain events <p>MBRC</p> <ul style="list-style-type: none"> response to Melioidosis outbreak due to flooding 	<p>Moreton Bay DERM</p> <ul style="list-style-type: none"> storm tide monitoring station at Mooloolaba - north of Caloundra and Bribie Island <p>Council's regionally based mosquito management program</p> <ul style="list-style-type: none"> aerial (helicopters) and ground treatments spray biological control products focused on saltmarsh areas - within 3-4 days after high tides

3.2.5 Ecosystem services

At the state level, the Qld Department of Environment and Resource Management (DERM) has wide responsibility for ecosystem services. Key state legislation includes: the *Water Act 2000*; *Vegetation Management Act 1999*; *Nature Conservation Act 1992*; *Marine Parks Act 1982*; *Fisheries Act 1994*; and the *Great Barrier Reef Marine Park Act 1975*. DERM is currently mapping areas including 'habitats, wildlife corridors, buffer zones and places supporting biological diversity or resilience'. Policies at the state level are focusing on creating biodiversity corridors that link parcels of remnant habitat across the landscape, increasing the capacity of species to migrate through these corridors to suitable new habitat areas in response to changing climatic conditions. Mechanisms such as purchasing land to create corridors are being pursued. Seasonal climate forecasting information has also been developed by the Queensland Climate Change Centre of Excellence.

In the GRC analogue community, policy and plans to protect ecosystem services have been developed at a regional level. Plans include the *Fitzroy River Basin Water Resource Plan* and the *Curtis Coastal Plan*, which will be superseded by the *Queensland Coastal Plan (QCP)*. A large part of the Curtis Coast is within the Great Barrier Reef World Heritage Area, which is subject to many statutory plans not listed here. Non-statutory plans that are relevant to the Curtis Coast region include the *state Infrastructure Plan*; catchment management plans or natural resource management plans such as the *Port Curtis Natural Resource Management Strategy*; a regional growth framework (*Central Queensland: A New Millennium*); integrated regional transport plans; the *Gladstone Port Authority Strategic Plan 1997–2047*; tourism strategies and the *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area*. The Gladstone region is biologically rich, with 46% of the state's bird species, 33% of its mammal species, 16% of its reptiles and 20% of its amphibians represented in the area (Gladstone Regional Council n.d.c, p.28). In addition, some 30 plant species are at either their southern or northern distribution limits. The area supports internationally significant breeding sites for loggerhead, green and flatback turtles, and the Baffle Creek system is one of the last un-impounded river systems in South-East Queensland. In the *Curtis Coastal Plan*, Gladstone Harbour and The Narrows are stated as being important to commercial and recreational fishing as they contain areas of high fisheries productivity, such as mangroves and seagrass that are critical for the long-term sustainability of fisheries inside and outside the harbour. There are four catchment working groups (CWG) in the Gladstone region: the Boyne Valley Catchment Working Group, the Calliope River Catchment Working Group, the Raglan Creek Catchment Working Group and the Bracewell Sub Catchment Working Group. A CWG is described as a collection of neighbouring property owners, with land along a common watercourse or water catchment area. GRC has been working with these groups on declared pest projects within their catchments. The Gladstone Area Water Board (GAWB) makes decisions on water restrictions and the provision of reticulated water is a direct responsibility of GRC. The *Gladstone Social Infrastructure Strategic Plan* (Gladstone Regional Council, 2009) lists a wide range of contributions that industry has made to enhance the services that ecosystems provide to the town and region. Examples include: parklands surrounding Gladstone resulting in the provision of extensive green space for the community; the Marina Parklands built by Gladstone Ports Corporation Limited and used by the community for recreational activities; Millennium Esplanade parklands at Boyne Island/Tannum Sands developed by Gladstone Regional Council; Awoonga Dam recreational facilities for community use and the Tondoon Botanical Gardens. While governance for ecosystem services is at a regional level, a community reference panel, drawn from economic, cultural and environmental interests, allows the aspirations and concerns of the people living in the catchment to be fully considered.

In the target area, the natural environment includes landscapes, topography, geology, soil types and water. The Moreton Bay Region is included in an area known as the Macleay-Macpherson Overlap, where the Torresian and Bassian biological distributions come together (Moreton Bay Regional Council 2011c). Plants and animals from sub-tropical areas occur together with those from the temperate south. The region covers an array of habitats – sandy ocean beaches, mangroves, tidal creeks and rivers, marshlands, brackish and freshwater swamps and lagoons,

grasslands, woodlands and forests. This variation is reflected in a diversity of native plants and animals. The South-East Queensland area, with its geological and climatic variations, contains almost a third of Australia's plant species (Moreton Bay Regional Council 2011d). A MBRC program – the Moreton Bay Region Bushcare – provides the community with opportunities to learn more about the environment and participate in hands-on conservation and restoration activities. Volunteer Bushcare groups are active on more than 60 sites throughout the Moreton Bay region. In addition, the natural environment on eligible private property may be enhanced through assistance from MBRC's Land for Wildlife, Backyards for Wildlife and Voluntary Conservation programs.

In both communities, services provided by ecosystems are vital to sustaining the local economy and enhancing community involvement in natural resources management. In view of the state and regional focus of natural resources planning and management, finding differences in local responses that reflect the prevailing climate at a local level appears to be a challenge.

HEAT

The impact of heat on terrestrial ecosystems may relate to the type of agricultural crops, garden plants or type of street trees that can be sustained in each area. At a state level, a program has been identified to assist primary producers in making decisions about appropriate crops, noting that changes due to increases in temperature may affect the suitability of crops and agricultural production. Heat may also affect public access to National Parks, and regional or local recreational areas. Identifying ecosystems vulnerable to fire in hot weather and implementing appropriate burning regimes are part of improved fire management in National Parks (Department of Environment and Resource Management, 2009). However, in the GRC analogue community, such action was not explicitly noted.

In the MBRC target community, the recognition of the link between summer water temperatures and *Lyngbya* blooms may indicate an understanding of the impact of heat on ecosystem services, although climate is not the only factor leading to the blooms.

DROUGHT

The impact of drought on ecosystem services is manifested in the impacts of dry conditions on terrestrial ecosystems including vulnerability to fire, as well as on the quantity and quality of water resources. Improved fire management in National Parks is managed from the state level (Department of Environment and Resource Management, 2009). A Rural Water Use Efficiency program promotes water and energy management through information and advice on best practices in water management and energy efficiency, particularly in irrigation systems (Department of Environment and Resource Management, 2009). There is a State Planning Policy for Healthy Waters (SPP 4/2010) which seeks to improve water quality in waterways by ensuring planning and development assessment under the *Sustainable Planning Act, 2009*. This SPP also addresses artificial waterways, and management of storm water and wastewater for developments greater than a single dwelling. The reliance on alternate water resources such as stormwater and wastewater increases during drought conditions.

Water Allocation Plans have been developed by DERM for river systems such as the Fitzroy River in the analogue area. Gladstone currently relies on the Awoonga Dam, on the Boyne River south west of the city, as its sole source of water. The GAWB has undertaken significant scoping and preliminary work in relation to the construction of a 120km pipeline from the northern end of GAWB's raw water distribution system to the Lower Fitzroy River, securing an allocation of 30,000ML per year from the Lower Fitzroy River. There is a complex plan to address the impact of drought on water supply to industry and the urban community in the Gladstone area. The *Central Queensland Regional Management Framework* (Central Queensland Regional Planning

Advisory Committee, 2002) notes significant harmful effects of industry on water quality in rivers, through regulating flows in the interests of industrial production. The *Gladstone Region Vision 2028* (Gladstone Regional Council, n.d.b) notes that approximately 70% of the total value of agricultural production in the Gladstone Region was derived from livestock slaughtering and products. Crop production is 17% of total agricultural value. Hence, low rainfall may impact on the ability to use agricultural land for livestock grazing as well as growing crops such as cotton. A Drought Management Plan (DMP) has been developed which states that, in the event of a prolonged drought, options have been identified as potential solutions to ensure that the region not only has a sufficient supply but also maximises the use of its existing water resources. GAWB makes decisions on water restrictions. A Drought Management Team makes the decision to increase/reduce the restriction level based on various factors such as moisture available within the catchment; water levels of the source at the time of decision; the usage at the time and the projected timeframe before next trigger is reached and time of year, e.g. at the end of the wet season. A *Blue-Green Algae Action Plan* (Gladstone Area Water Board, 2009), based on state and national guidelines and on advice from BGA experts, also attempts to protect ecosystem services during times of drought.

In the target community, which is in the South East Queensland (SEQ) Region, the effect of drought on ecosystem services has resulted in a focus on water efficiency, water security and the management of the region's water resources to ensure the health of the environment, particularly the waterways and bays (Department of Environment and Resource Management, 2009; Queensland Water Commission, 2010). The *SEQ Water Strategy* (Queensland Water Commission, 2010) provides a comprehensive planning and implementation framework to secure water supplies for SEQ for 50 years. The framework includes the establishment of permanent water restrictions across the region and a development of alternative water resources such as recycled wastewater. South-East Queensland Irrigation Futures addresses the water efficiency of irrigated agriculture in the SEQ region affected by drought conditions. The MBRC provides alternative sources of water such as recycled water from its wastewater treatment plants to reduce the draw on local water resources in times of drought. The permanent water requirement of frogs and other aquatic species has been noted in community education publications such as the brochure, *Living with the Environment - Frogs*.

Drought conditions have occurred in both communities and have resulted in the establishment of similar response mechanisms due to the state or regional basis for water planning and establishment of catchment groups, hence differences are not immediately evident.

BUSHFIRE THREAT

The impact of bushfire threat on ecosystem services manifests itself through policies and plans to prevent bushfires in areas occupied by humans and in catchments where water sources are used by humans and may become contaminated through ash, dead animals, particles or smoke and to improve management of fire-dependent and fire-adapted ecosystems and habitats for threatened species (Queensland Government, 2009b). At the state level, QH's fact sheet on *Bushfires and Water Tanks* also addresses impact on watercourses and other storages. Ecosystems that are vulnerable to bushfire, as well as those dependent or adapted to bushfire, need to be identified to enable appropriate fire management regimes to be implemented.

The analogue area of Gladstone has an extensive network of parks and areas where bushfire may occur. The GRC has developed emergency management plans and refers rural landowners to the Queensland Rural Fire Service (QFRS) for advice to address the prevention of damage to property, animals and crops arising from bushfire. Similar advice is issued in the target area of MBRC. Other effects of bushfire noted in the target area include advice about the need for bushfire events to effectively manage native vines in ecosystems where native vines become a problem (Moreton Bay Regional Council, 2011e). Hence the reliance of bushfire events to manage native vines may conflict with the needs of humans such as for agriculture.

Little difference was observed in the responses to bushfire on ecosystems with policies at the state level driving action at the local level in both communities.

HIGH VELOCITY WIND

The impact of high velocity wind on ecosystem services relates to the ability for humans to obtain a benefit from ecosystems during these climatic conditions. The SPCM states that 'Coastal environments constantly adapt to change as a result of dynamic natural processes, such as storms and cyclones' (p.3). Buffers along the coast were the main evidence of action in each community to address the effect of high velocity wind on ecosystem services. In the analogue area, up to 10m of erosion occurring adjacent to parts of the urban area at Agnes Water Beach was noted as a result of Cyclone Hamish in early 2009. A draft *Agnes Water Seventeen Seventy Shoreline Erosion Management Plan (AWSSSEMP)* had been developed which identifies an immediate erosion threat width at the Agnes Water Beach to be 35m and an average long term erosion rate of 0.35m/yr' (Gladstone Regional Council, 2010f p.28). Similarly, in the MBRC target area, the beach along Bribie Island had been identified as an area subject to erosion during high wind events. Numerous bushcare groups including Friends of Woorim Beach have contributed to the Bribie Island beach erosion stabilisation project.

The differences between the responses to effects of high wind events on ecosystem services are not apparent as the state-driven responses such as erosion management plan requirements for buffer zones and coastal set-backs mask the local responses to cyclones or strong winds.

FLOODING/INTENSE RAINFALL

The floodplain in the urban setting is used for many activities including recreation. The effect of flooding and intense rainfall on ecosystem services manifests itself in the development of systems to maintain both the quantity and quality of water during these events. The *State Planning Policy (SPP 4/2010) for Healthy Waters* (Department of Infrastructure and Planning 2010d) seeks to improve water quality in waterways by ensuring that development is assessed under the *Sustainable Planning Act 2009*. This SPP also addresses artificial waterways, and management of storm water for developments. Water Resource (Basin) Plans for catchments across Queensland address environmental flows and provide a framework for minimising, where practicable, degradation in natural ecosystems. Catchment Working Groups also have a responsibility to control outbreaks of noxious weeds on strategic parcels of land within their catchment to prevent weed seed spreading downstream in times of flood.

In the GRC analogue area, an example of using flooding to enhance ecosystem services was the *Auckland Creek Flood Study Report* (Gladstone City Council, 2006). GRC developed a proposal to construct a water retardation basin to reduce the incidence of flooding (and erosion) along the embankments of Tigalee Creek at Sun Valley during heavy rain events. The solution also enhanced visual aesthetics and minimised environmental impact. As coastal environments constantly adapt to change as a result of dynamic natural processes, such as floods (Queensland Environmental Protection Agency 2002, p.3), the effect of flooding and intense rainfall extends to the coastal environment. In the GRC analogue community the *Port Curtis Integrated Monitoring Program (PCIMP)* has been implemented to monitor the condition of the aquatic environment adjacent to the City of Gladstone.

In the target area, the *South East Queensland Healthy Waterways Strategy 2007-2012 (SEQHWS)* requires an ongoing ecological health assessment of all major estuarine and freshwater ecosystems in South-East Queensland (South East Queensland Healthy Waterways Partnership 2007). A report card has been produced which provides a grading of the waterways. Floodplains represent one of the most common landforms in the analogue Moreton Bay region covering approximately 20% or 400 square kilometres (Moreton Bay Regional Council, 2011f). A

Regional Floodplain Database project is currently underway in MBRC area which is producing floodplain maps such as that depicted in Figure 5. The broadest floodplains in the region include the coastal floodplains of the Pine River, Hays Inlet, Caboolture River and Pumicestone Passage catchments and the westward flowing Stanley River. The flooding in the catchments of rivers emptying into Moreton Bay in January 2011 are testament to the effect of intense rainfall on the ability of coastal plains ecosystems to treat the sediment that flows to the coast during such events and the impact on humans who use these natural environments for recreation or for generating their income.



Figure 5 Example of floodplain maps produced in the MBRC Regional Floodplain Database Project (Source: Moreton Bay Regional Council 2011g).

While flooding and intense rainfall occur in each of the analogue and target communities, there are extensive networks of wetlands in the GRC analogue area which the state government agencies have protected through policies and plans. See Box 5 for further information about the significance of services provided by floodplains and wetlands during climatic events that produce floods. The services provided by these ecosystems have assisted in flood management and protection of coastal water quality. While floodplain mapping is most evident in the target community, the effect of floods on coastal water quality was noticeable following the January 2011 floods. The target area may be able to learn from the policy and plans implemented in the analogue area which have led to the protection of the wetlands from development.

Box 4 Services Provided by Floodplains and Wetlands

Box 5. Services provided by floodplains and wetlands

The floodplain in the urban setting is increasingly being used for many activities including recreation. However the importance of maintaining floodplains and wetlands has been highlighted by the differences in the impact of the floods in Queensland in the two communities studied. In the analogue community, a Temporary State Planning Policy (TSPP 1/10) which focuses on protecting wetlands of high ecological significance in Great Barrier Reef Catchments applies to the entire Gladstone Regional Council (GRC) area. TSPP 1/10 seeks to 'ensure that development does not occur in, or impact on, a wetland of high ecological significance'. GRC has already identified numerous wetlands and buffer areas if the temporary policy was to become permanent (Gladstone Regional Council 2010c, p.28). In the GRC area there are 1339 wetlands of which 358 are estuarine (mangroves and tidal flats) and 379 are riverine wetlands. (Environmental Protection Agency 2005). Of the almost 774 sq km of wetlands in the area, 67.4% are estuarine and 12.7% are riverine. The photograph was taken in January 2011 and shows some of the estuarine wetlands in Gladstone. The services provided by these extensive networks of wetlands in the analogue area in times of flood and intense rainfall have assisted in flood management and protection of coastal water quality. The performance of the wetland systems at Gladstone during the recent record floods of December 2010-January 2011 is testament to the presence of policy that protects riverine and estuarine wetlands from development, maintaining their function and minimising impact to the local community.



Examples of estuarine wetlands at Gladstone (Photo: C Hamilton January 2011)

COASTAL

The effect of coastal climatic factors on ecosystem services in Queensland has resulted in coastal planning policy and coastal plans. Development under the *Sustainable Planning Act 2009* is subject to the State Planning Policy for Coastal Protection (SPPCP), while management planning, activities, decisions and works that are not assessable under the *Sustainable Planning Act 2009* are addressed through the State Policy for Coastal Management (SPCM). A new Queensland Coastal Plan (QCP) was approved in March 2011 but has yet to be implemented. The SPCM defines coastal land and coastal resources and states that 'Coastal environments constantly adapt to change as a result of dynamic natural processes, such as tides, waves, floods, storms and cyclones, and changes in sea level' (p.3).

DERM monitors storm tides at various sites along the coast –each storm tide gauge is accessed once a day, between 5.00 am and 7.00 am Australian Eastern Standard Time. During tropical cyclones or other extreme events, the frequency of update is increased at affected locations.

In the analogue GRC area, the effects of coastal climatic factors on ecosystem services may be addressed through management strategies and actions outlined in the *Curtis Coastal Plan*. Coastal climatic events have impacted on the ecosystems in the area with 10m of erosion occurring along Agnes Water Beach as a result of Tropical Cyclone Hamish in early 2009. A draft Agnes Water Seventeen Seventy Shoreline Erosion Management Plan (AWSSSEMP) has been

developed to address the immediate erosion threat width of about 35m and an average long term erosion rate of 0.35m/yr' (Gladstone Regional Council, 2010f p. 28)

Near the target MBRC area, numerous bushcare groups including Friends of Woorim Beach have contributed to the Bribie Island beach erosion stabilisation project (see Figure 6). DERM has also installed a storm tide monitoring station at Mooloolaba, north of Caloundra and Bribie Island.

The differences between the responses to coastal climatic events are not significant as the state level responses, such as coastal plans and erosion management plans, mask local responses.



Figure 6 Example of beach erosion stabilisation at Woorim Beach, Bribie Island (Photo: C. Hamilton, January 2011)

SUMMARY

See Table 18 for a summary of the analysis of ecosystem services policy and plans for response to climatic factors for Gladstone and Moreton Bay. State level policies for managing natural resources, including coastal ecosystems, require management of native vegetation, water resources, water quality and coastal zones, and direct the development of regional and local management strategies and plans for natural resources. Hence, there is significant direction from the state level toward action at the local level. Areas where the target community may learn from the analogue community relate mainly to ensuring that ecosystems provide adequate service during flooding and intense rainfall by restricting development and providing stormwater detention infrastructure that has ecosystem components. Ecosystems in the analogue area appeared to offer greater service in managing recent floods compared to those in the target area, although both experienced major periods of intense rainfall and significant flooding. The pressure of population growth in the target area may have forced the development of land in floodplains and hence the extensive floodplain mapping database project underway in the target community.

Table 17 Analysis of integration of climate factors into ecosystem services policies, plans and processes for Gladstone and Moreton Bay

Gladstone – Moreton Bay					
Heat	Drought	Bushfire threat	High velocity wind	Flooding /Intense rainfall	Coastal
<p>Gladstone Queensland Coastal Plan (QCP) previously Curtis Coastal Plan</p> <ul style="list-style-type: none"> ocean warming pressure on inshore coral reef systems 	<p>Gladstone Gladstone Area Water Board</p> <ul style="list-style-type: none"> drought management plan water conservation initiatives 	<p>Gladstone No evidence</p>	<p>Gladstone Queensland Coastal Plan</p> <ul style="list-style-type: none"> quantifies the state's response to climate change as it relates to cyclone intensity and coastal erosion 	<p>Gladstone Auckland Creek Flood Study Report (2006)</p> <ul style="list-style-type: none"> need to reduce flooding (and erosion) along Tigalee Creek at Sun Valley during heavy rain events <p>Catchment Working Groups</p> <ul style="list-style-type: none"> control outbreaks of noxious weeds on strategic parcels of land within their catchment to prevent weed seed spreading downstream in times of flood 	<p>Gladstone QCP – previously Curtis Coastal Plan</p> <ul style="list-style-type: none"> erosion prone area maps published on DERM's website. 7 shoreline erosion management plans (SEMP) required <p>Agnes Water Seventeen Seventy SEMP (draft)</p> <ul style="list-style-type: none"> measuring erosion - beach has an immediate erosion threat width of about 35m and an average long term erosion rate of 0.35m/yr' <p>DERM</p> <ul style="list-style-type: none"> storm tide monitoring sites along the coast – once a day, more frequently during tropical cyclones or other extreme events
<p>Moreton Bay State level - ClimateQ - Improved fire management in National Parks</p> <ul style="list-style-type: none"> will identify ecosystems vulnerable to fire in hotter conditions and implement appropriate burning regimes 	<p>Moreton Bay Moreton Bay Regional Council</p> <ul style="list-style-type: none"> <i>Living with the Environment - Frogs</i> Highlights that frogs need permanent water <p>ClimateQ - Improved fire management in National Parks</p> <ul style="list-style-type: none"> will identify ecosystems vulnerable to fire in drier conditions and implement appropriate burning regimes 	<p>Moreton Bay Moreton Bay Regional Council –</p> <ul style="list-style-type: none"> <i>Living with the Environment – vines of the Moreton Bay region</i> Natural bushfire events manage native vines. 	<p>Moreton Bay Queensland Coastal Plan</p> <ul style="list-style-type: none"> quantifies the state's response to climate change as it relates to cyclone intensity 	<p>Moreton Bay MBRC Maps –</p> <ul style="list-style-type: none"> areas of potential inundation of the ground surface during a '1 in 100 year' flood Flood studies prepared by the former Caboolture, Redcliffe and Pine Rivers Councils. <p>Moreton Bay Regional Council</p> <ul style="list-style-type: none"> Pine Rivers Fish Management Association runs a native fish breeding program. The program aims to produce native fish for mosquito control in fresh water dams and ponds on private property. 	<p>Moreton Bay DERM</p> <ul style="list-style-type: none"> storm tide monitoring station at Mooloolaba, north of Caloundra and Bribie Island <p>Coastal Dune Ecosystems – Bribie Island</p> <ul style="list-style-type: none"> beach erosion stabilisation project – numerous groups including Friends of Woorim Beach, Bribie Island Community Association; Bribie Island Environmental Protection Association; MBRC & Australian Government (funding)

3.4 LIST OF REFERENCES - QUEENSLAND

Table 18 Summary of references for Queensland pairing

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
STATE							
Department of Environment and Resource Management 2011. <i>Queensland Coastal Plan</i> . The State of Queensland, Brisbane. http://www.derm.qld.gov.au/coastalplan/pdf/qcp-web.pdf	LUP					#	#
Department of Natural Resources and Water 2007. <i>Queensland Urban Drainage Manual (QUDM)</i> . The State of Queensland, Brisbane.	Inf					#	
Department of Infrastructure and Planning 2003). <i>State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide</i> : The State of Queensland, Brisbane	LUP, Inf			#		#	
<i>Disaster Management Act 2003</i> , (Government of Queensland)	Health				#	#	#
Emergency Management Queensland, <i>Preparing for Cyclones</i> , The State of Queensland, Brisbane.	Health				#	#	#
Queensland Environmental Protection Agency 2002. <i>State Coastal Management Plan</i> , The State of Queensland, Brisbane. http://www.derm.qld.gov.au/environmental_management/coast_and_oceans/coastal_management/state_coastal_management_plan/	LUP						#
Walsh, A. and Stewardson, J. 2002. <i>The shifting sands of jurisdictional responsibility in coastal management</i> , Environmental Protection Agency, Queensland	Inf						#
ANALOGUE – GLADSTONE							
Bureau of Meteorology 2011. 'Tropical Cyclones Eastern' http://www.bom.gov.au/cyclone/history/eastern.shtml	Health				#		

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Cardno (Qld) Pty. Ltd. 2006. <i>Agnes Water & Town of 1770 Water Integrated Water Management Strategy</i> . Prepared for Miriam Vale Shire Council. http://www.gladstone.qld.gov.au/web/guest/gladstone-airport?p_p_id=20&p_p_lifecycle=1&p_p_state=exclusive&p_p_mode=view&_20_struts_action=%2Fdocument_library%2Fget_file&_20_folderId=1746856&_20_name=DLFE-34142.pdf	Inf		#				
Central Queensland Regional Planning Advisory Committee 2002. <i>Central Queensland Regional Plan (Central Queensland Regional Growth Management Framework)</i> , The State of Queensland, Brisbane. http://www.dlqp.qld.gov.au/resources/plan/regional-growth/cqrgfm.pdf	LUP;		#				#
Department of Infrastructure and Planning 2010a. <i>Draft Wide Bay Burnett Regional Plan</i> . The State of Queensland, Brisbane. http://www.dlqp.qld.gov.au/resources/plan/wide-bay/draft-plan/draft-wbb-regional-plan.pdf	LUP						#
Department of Local Government, Planning, Sport and Recreation and the Wide Bay Burnett Regional Organisation of Councils 2005. <i>Wide Bay Burnett Regional Plan 2007 – 2027</i> . The State of Queensland, Brisbane. http://www.dlqp.qld.gov.au/resources/plan/wide-bay/wbbrplan.pdf	LUP		#				#
Department of Natural Resources and Water 2006. <i>Central Queensland Regional Water Supply Strategy (CQRWSS)</i> The State of Queensland, Brisbane. http://www.gawb.qld.gov.au/downloads/cqrwss_report_dec06.pdf	Inf		#				
Department of Water 2000. <i>Water Resource (Boyne River Basin) Plan</i> . The State of Queensland, Brisbane.	Eco					#	
Environmental Protection Agency 2003. <i>The Curtis Coastal Plan Regional Coastal Management Plan (Curtis Coastal Plan)</i> . The State of Queensland, Brisbane. http://www.derm.qld.gov.au/environmental_management/coast_and_oceans/coastal_management/regional_coastal_management_plans/curtis_coast.html	LUP;						#
Gladstone Area Water Board 2009. <i>Blue Green Algae Action Plan</i>	Health		#				

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Gladstone Area Water Board 2007 <i>Drought Management Plan</i> . http://www.gawb.qld.gov.au/downloads/DMP.pdf	Inf		#				
Gladstone City Council 2006. <i>Auckland Creek Flood Study Report</i> .	Eco					#	
Gladstone Regional Council (n.d.a), <i>Community Disaster Awareness Guide</i>	Health					#	
Gladstone Regional Council (n.d.c) <i>draft Agnes Water Seventeen Seventy Shoreline Erosion Management Plan</i>	Eco						#
Gladstone Regional Council (n.d.d)							
Gladstone Regional Council 2011b. <i>Multilingual Natural Disaster Fact Sheets</i> . http://www.gladstone.qld.gov.au/web/guest/multilingual-natural-disaster-factsheets	Health				#	#	
Gladstone Regional Council 2010c. <i>Our Place Our Plan: Towards a new Planning Scheme. A Discussion Document</i> . Released for public comment from 16 June, 2010 to 11 August, 2010 http://www.gladstone.qld.gov.au/c/document_library/get_file?uuid=cd8c54be-8d33-452f-b100-589a14eb480d&groupId=1570002	LUP, Eco	#	#	#		#	
Gladstone Regional Council 2010d. <i>Factsheet: Tigalee Creek Project</i> . Community Relations section, Gladstone Regional Council http://www.gladstone.qld.gov.au/c/document_library/get_file?uuid=c4344bec-455f-4949-b5a6-82e489494c16&groupId=1570002	Inf					#	
Gladstone Regional Council 2009. <i>Gladstone Region Social Infrastructure Strategic Plan</i>	Health					#	
Moran, K. 2010. 'Floods block crucial help', <i>The Observer</i> , 31 December.	Health					#	
Padgett G. 2006 'Cyclone Sose', http://australiasevereweather.com/cyclones/2001/summ0104.htm	Health						#

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
<i>The Observer</i> 2011. Weather may cut city power supply, Gladstone, 1 January.	Inf					#	
Queensland Government Rural Fire Service, (n.d.) Prepare.Act.Survive brochure, The State of Queensland, Brisbane.	Health			#			
Sinclair, Knight, Merz 2006. <i>The Gladstone Plan</i> , prepared for City of Gladstone. http://tpscheme.gladstonerc.qld.gov.au/formergladstonecity/gladstone.html	LUP	#	#	#	#	#	
TARGET – MORETON BAY							
Aitken, A. and Losee, S. 2006. To A/C or not to A/C? That is the Question. <i>Proc. of Subtropical Cities Conference</i> . Queensland University of Technology. 27-29 September. http://www.subtropicalcities2006.qut.edu.au/documents/Papers%20Page/Papers/Aitken%20-%20To%20AC%20or%20not%20to%20AC.pdf	H/B	#					
Bureau of Meteorology 2011c. 'Tropical Cyclone Dora', Commonwealth Government of Australia. http://www.bom.gov.au/cyclone/history/dora.shtml	Health				#		
Caboolture Shire Council 2010. <i>Caboolture ShirePlan</i> , http://www.moretonbay.qld.gov.au/subsite.aspx?id=73667&libID=76218	LUP			#			
Caboolture Shire Council 2002. <i>Urban Stormwater Management Strategy</i> , www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/environment/waterways/Urban%20Stormwater%20Management%20Strategy%20Report.pdf).	Eco					#	
Climate Risk Pty Limited 2009. <i>Scoping Climate Change Risks for MBRC</i> . Prepared for Moreton Bay Regional Council. August 2009 http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/environment/Scoping-Climate-Change-Risk.pdf	LUP, Inf				#		#
Department of Employment, Economic Development and Innovation 2010. <i>South East Queensland Water Grid</i> . The State of Queensland, Brisbane. http://www.dip.qld.gov.au/seqwatergrid	Inf		#				
Department of Environment and Resource Management 2009. <i>South East Queensland Natural Resource Management Plan 2009–2031</i> , The State of Queensland, Brisbane.	Eco		#				

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
http://www.seqcatchments.com.au/_webapp_145854/Draft_SEQ_NRM_plan							
Department of Infrastructure and Planning 2010a. <i>South East Queensland Infrastructure Plan and Program 2010–2031</i> (SEQIPP), The State of Queensland, Brisbane. http://www.dlgp.qld.gov.au/resources/plan/SEQIPP/dip-seqipp-10.pdf	Inf		#				
Department of Infrastructure and Planning 2009a. <i>South East Queensland Regional Plan</i> . The State of Queensland, Brisbane. http://www.dlgp.qld.gov.au/resources/plan/SEQ/regional-plan-2009/seq-regional-plan-2009.pdf	LUP			#		#	#
Department of Infrastructure and Planning 2009b. <i>South East Queensland Climate Change Management Plan - Draft actions to implement the climate change policies of the South East Queensland Regional Plan 2009–2031</i> . The State of Queensland, Brisbane. http://www.dlgp.qld.gov.au/resources/plan/SEQ/draft-climate-change-management-plan.pdf	LUP	#	#	#	#	#	#
Department of Infrastructure and Planning 2009c. <i>Part F–South East Queensland Regional Plan 2009–2031 State planning regulatory provisions</i> http://www.dlgp.qld.gov.au/resources/laws/state-planning-regulatory-provision/seq-regional-plan-2009-20031-sprp.pdf	LUP	#	#	#	#	#	#
Department of Local Government and Planning 2011. <i>Climate Change Adaptation</i> . The State of Queensland, Brisbane. http://www.dlgp.qld.gov.au/regional-planning/adaptation.html	Inf	#	#	#	#	#	#
Granger, K. 2005. <i>Heatwave Risks in South-East Queensland: a Macro Analysis</i> . Brisbane City Council.	H/B	#					
Hodges J.C. 1971 Clontarf, photograph http://www.photosau.com/RedcliffeLibrary/scripts/ExtSearch.asp?SearchTerm=000073	Health						#
John Wilson and Partners Pty Ltd 2004. <i>Griffin Area Flood Study</i> , Prepared for Pine Rivers Shire Council. October 2005. http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/residents/Griffin-Area-	Inf					#	

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Regional-Flood-Study.pdf							
Kovats, R.S. and Ebi, K. 2006. Heatwaves and Public Health in Europe. <i>European Journal of Public Health</i> . 16(6):592-599.	H/B	#					
Landmarc Ltd 2003. <i>Pine Rivers Shire Council – Bushfire Management Strategy</i> . Prepared for Pines Rivers Shire Council http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/living/health/bush%20management%20strategy.pdf	Inf			#			
Losee, S., Herron, J. and Nolan, M. 2007. <i>Climate Change and Energy Taskforce</i> Final Report. Report prepared by Maunsell Australia Ltd for the Brisbane City Council. 12 March.	H/B	#					
Moreton Bay Regional Council 2008. <i>Mosquitoes Advice to Residents</i> - Advertisement http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/living/health/Jan%2008%20Mosquito%20Ad.pdf	Health					#	
Moreton Bay Regional Council, (n.d.), <i>How to Stay Safe in a Heatwave</i>	Health	#					
Moreton Bay Regional Council, DoTARS and Queensland Government Emergency Management Queensland, (n.d.) 'be Storm safe' brochure	Health				#		
Moreton Bay Regional Council 2011b. Bushcare Understorey Newsletter http://www.moretonbay.qld.gov.au/uploadedFiles/common/forms/environment/Bushcare-Understorey.pdf .	Health					#	
Moreton Bay Regional Council 2011c. 'Environmental Pests and Weeds', http://www.moretonbay.qld.gov.au/environment.aspx?id=1732	Eco			#			
Moreton Bay Regional Council 2011d. Regional Floodplain Database Project, http://www.moretonbay.qld.gov.au/council.aspx?id=62367	Eco					#	

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Moreton Bay Regional Council 2008. Planning Scheme Policy for the <i>PineRiversPlan</i> PSP17 Demonstrating Compliance with the Major Flood Events Overlay Code http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/development/planning/pine-rivers/PSP17%20Demonstrating%20Compliance%20with%20the%20Major%20Flood%20Ev%20ents%20Overlay%20Coded.pdf	Inf					#	
ourbribie.fm, http://www.ourbribie.com.au/cycloneprep.html	Health	#			#		
Seqwater 2010. <i>Strategic Plan 2010-11 to 2014-15</i> . Queensland Bulk Water Supply Authority, The State of Queensland, Brisbane. http://www.seqwater.com.au/public/sites/default/files/userfiles/file/pdfs/Seqwater2010-15%20Strategic%20Plan%20final.pdf	Inf		#				
South East Queensland Healthy Waterways Partnership (2007) <i>SEQ Healthy Waterways Strategy 2007- 2012 Strategy Overview</i> http://www.healthwaterways.org/TheStrategy.aspx	Eco		#				
Queensland Water Commission 2010. <i>South East Queensland Water Strategy</i> http://www.qwc.qld.gov.au/planning/pdf/seqws-full.pdf	Eco		#				
The Institute for International Development 2007. <i>Caboorture Shire Natural Disaster Risk Management Study</i> , Prepared for the Caboorture Shire Council.	Inf				#		
WorleyParsons 2009. Resource & Energy <i>Lower Pine River Flood Study</i> . Prepared for Moreton Bay Regional Council. June 2009. http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/residents/LPFS.pdf	Inf					#	

4 WESTERN AUSTRALIA

4.2 TARGET AND ANALOGUE PAIRS

One analogue/target pairing was studied in Western Australia. Both were regional councils.

4.2.5 The City of Geraldton-Greenough

Geraldton, Western Australia, is located approximately 424km north of Perth (City of Geraldton-Greenough, n.d.a). The Chapman Valley is located to the north of Geraldton and the Moresby ranges to the south (City of Geraldton-Greenough, n.d.b). The City of Geraldton-Greenough is 1781.1 km² in area and is situated on the Indian Ocean.

In 2009, the total regional population consisted of 37,895 people. This is compared to 35,049 people in 2006. 23.2% of the population was aged between 0 to 14 years old, with 11.5% of the populace over the age of 65.

As a major outer regional city, key industries and the economic base of the Geraldton region include agriculture; fishing; mining and mineral processing and coastal tourism. For example, the area contains a world leading rock lobster fishery, with '5000 tonne produced in the Mid West region from the 2007/08 season' (City of Geraldton Greenough n.d.c). The Council has also been internationally recognised for its' deliberative demographic experiment, known as the '2029 and Beyond Project' (see City of Geraldton Greenough n.d.d.)

The current City of Geraldton-Greenough was formed in 2007, through the amalgamation of the former City of Geraldton and the Shire of Greenough. As of July 2011, the City of Geraldton-Greenough is amalgamated with the Shire of Mullewa.

4.2.6 City of Bunbury

The City of Bunbury, Western Australia is located approximately 175km north of Perth. The council region is 65.3km² in area. It is situated close to the Indian Ocean, and contains the Leschenault Estuary and Koombana Bay (City of Bunbury n.d.a).

In 2009, the total regional population consisted of 33, 979 people. This is compared to 31,712 people in 2006. 18% of the population was aged between 0 to 14 years old, with 13.9% of the populace over the age of 65.

As an inner regional city and the centre of the South West region of Western Australia, the key industries and economic base of the City of Bunbury include: 'retail, manufacturing, construction, health and community services' as major employment sectors, as well as an important higher educational centre (City of Bunbury n.d.a). The area is also a major tourism centre, with features such as coastal tourism and the Margaret River Wine Region.

4.3 POLICY ANALYSIS

4.3.5 Land Use Planning

Planning in Western Australia is carried out under the framework of the *Planning and Development Act, 2005*. The Minister for Planning and Infrastructure oversees the system,

working with the Western Australian Planning Commission (WAPC), which sets the strategic framework for planning in the *State Planning Strategy*. The WAPC is responsible for determining all subdivision applications. The WAPC prepares State Planning Policies such as the *State Policy for Coastal Planning* and the *Residential Design Codes* (R- Codes). Due regard must be given to these policies in making planning schemes and decisions on development (Western Australian Planning Commission, 2006a p2). WAPC also prepares Planning Bulletins on a range of issues. The R- Codes include a section on Design for Climate Requirements (Western Australian Planning Commission, 2010). This notes that design should be appropriate to climate in respect to Climate Zones 4, 5 and 6 as set out in the BCA. Provisions cover siting of residential development to ensure passive and active access to solar gain and a requirement that storm water must be directed from roofs and other non permeable surfaces to gardens, sumps or rainwater tanks (Section 6.9).

Western Australia is divided into 144 local government areas which prepare local planning schemes and make decisions on development applications. Local governments also prepare local planning policies, of both a formal and informal nature, with regard to the State Planning Framework. To help local governments prepare, examine and review planning schemes, the WAPC has adopted the *Model Scheme Text*. This provides standard clauses, terms and provisions for greater consistency in the basic legal and administrative provisions of planning schemes.

In some areas, Regional Planning schemes are prepared. These normally cover more than one local government area and deal with strategic issues such as infrastructure and open space planning. Not all areas of the state are covered by Regional Planning Schemes, but where they do exist WAPC has power of determination, which in most cases it devolves to local government. Where WAPC considers that a development proposal has regional significance it may insist on determining its outcome. The WA Planning System is heavily centralised, with the WAPC wielding more power in respect to decision making on development applications than in many other states.

GERALDTON- BUNBURY PAIRING

The previous two local government areas of the City of Geraldton and the Shire of Greenough have combined to form the City of Geraldton-Greenough. The *Greater Geraldton Structure Plan*, which covers the regional centre of Geraldton, is currently undergoing amendment (2011). The City has three gazetted local planning schemes in operation, namely *Town Planning Scheme No 3 (Geraldton)*, *Town Planning Scheme No 1A (Greenough River Resort Estate)* and *Local Planning Scheme No 5 (Greenough)*. The Shire of Chapman Valley continues to operate from *Town Planning Scheme No 1*. A review of local planning schemes is being undertaken (Western Australian Planning Commission 2010, p2). Planning policy in Geraldton is situated within the broader context of the *Greater Geraldton Regional Plan* (1999). This is a wide ranging document which discusses issues and policy that extends beyond the traditional scope of statutory land use planning and covers infrastructure, ecosystem services and agriculture.

In a system which is heavily reliant on state policy, we would expect to find any planning policy response to climatic factors at this level. In fact, state policy on Natural Hazards and Disasters comments that '*Western Australia is subject to a range of natural disasters such as floods, cyclones, storm surge, severe storms, landslide, bush fires and earthquakes. The cost of recovery and response activities associated with these disasters is immense. The most effective strategy for reducing the long-term impact of natural hazards is to integrate mitigation activities into the process of land use planning*' (Western Australian Planning Commission, 2006b, p1533). This guidance permeates as far as the regional tier of policy where the Batavia Regional Organisation of Councils, which includes the City of Geraldton-Greenough (CGG), has produced the *Batavia Regional Organisation of Councils' Climate Change Action Plan* (AECOM Australia Pty. Ltd., 2010), which is referred to as *BROC CCAP* for the remainder of this document. Whilst not a statutory land use planning document, this plan has been designed with the purpose of

developing governance and management tools to integrate climate risks into decision-making in major projects, e.g. land developments, coastal infrastructure and major purchases (p.36). Apart from the general objective of implementing policy to '*promote and contribute to the economic opportunities and social wellbeing of the municipality and the community*' (p.10) that could implicitly be viewed as taking climatic considerations into account, the Geraldton Planning Scheme, which predates the *BROC CCAP*, does not appear to contain any explicitly climate related policy.

HEAT

There is no reference to heat or temperature in any of the current planning schemes for Geraldton beyond the observation in the *Greater Geraldton Regional Plan* that higher winter temperatures, compared to more southerly locations, may provide the area with a competitive advantage in respect to certain agricultural activities (p.61). Whilst planning documents show photographs of shade structures in parks and playgrounds, there appears not to be any specific policy relating to the provision of shade in public areas. However, more recent policy, such as the *BROC CCAP*, makes a range of suggestions relating to coping with heat, including identifying cool recreation spaces such as libraries, community centres and swimming pools that have capacity to expand, considering potential design and operational changes and monitoring usage during heat waves (p.31). A likely future requirement for a revision to shading requirements in residential developments is also noted (p.24). In Bunbury the Local Planning Scheme makes reference to the requirement for planting in public places to reduce radiant heat and encourage water infiltration (p.29).

DROUGHT

State Planning Policy 2.9 *Water Resources* notes the potential impact of climate change on water resources and that 'Land use planning, in conjunction with other mechanisms, can assist in protecting, conserving, managing and enhancing the state's water resources' (Western Australian Planning Commission, 2006c, p.5711). This document makes it clear that across WA water is viewed as a critical factor to be taken into account when making planning decisions. Its availability is clearly a function of climatic factors. The *Greater Geraldton Regional Plan, 1999*, discusses regional infrastructure requirements including water supply. This aspect is therefore discussed below under Infrastructure. It also notes water availability as a constraint on development (p.83). The *Draft Greater Geraldton Structure Plan* notes that relatively low rainfall leads to a reliance on groundwater, the long-term sustainability of which is uncertain (p8). Beyond that observation there is no explicit discussion of climate factors in the Plan. *Local Planning Scheme No 5 (Greenough)*, Section 5.13 - Water Resources, notes that local government must have regard to managing water balance, water quality, water conservation and environmental values with development along waterways, wetlands and estuaries.

The *BROC CCAP* is more explicit in respect to water issues, confirming that planning decisions should 'Continue implementation of the Better Urban Water Management Strategy required under State Planning Policy 2.9 Water Resources' (p.32), provide incentives to encourage residential and commercial uptake of rainwater tanks (p.31) and that low water intensity dust suppression methods are used in Council's construction activities (p.31) It also notes that CGG should consider an urban growth boundary in the Local Planning Strategy and Town Planning Schemes as a high level response to conservation of water resources (p.31)

Whilst for the most part, land use planning policy in respect to water is driven by the state, an increasing awareness of the precarious nature of water supply in the context of an expanding mining economy and a restructuring agricultural sector is becoming apparent in recent high level regional planning policy documents. The suggestion that an urban growth boundary is necessary on water resource grounds is unusual and indicative of the serious constraint that water supply

places on urban development in Geraldton. Concern about this issue was reinforced in interviews with the State Department of Environment and Conservation, Climate Change Unit (Interview, 23 February 2011), which noted the Northern Agricultural Region as a hot spot for climate change, particularly in terms of declining rainfall. Further impacts of declining water resources on land use planning include reduced ability to irrigate public parks and reserves and hence a likely reduction in the amount of such spaces to be included in future developments, the need to capture more storm water in order to lessen the burden on reticulated supplies (p24) and setting water use targets (p.27). Concern over water resource shortages was also evident from interviews with WA Department Agriculture and Food (Interview 18 February 2011). Here it was suggested that a pilot study be undertaken using land capability techniques to examine the potential for buyback of agricultural properties.

BUSHFIRE THREAT

The *Geraldton Regional Plan* notes bushfire risk as one of a list of constraints on development (p.83). General policies relating to siting of development in respect to fire risk and potential conflict with biodiversity policies are contained in State Planning Policy 3.7 *Planning for Bushfire Protection*. The *Homeowner's Bush Fire Survival Manual* (2004) also includes design guides for housing; situation of housing; windbreaks etc. Local planning schemes do not appear to contain any reference to bushfire risk as this is dealt with by state wide planning controls. More recent policy advice in the form of the *BROC CCAP* reviews bushfire management planning mechanisms (e.g. *WAPC Planning for Bushfire Protection* tool, *City of Geraldton-Greenough Bushfire Emergency Response Plan*) to ensure it anticipates changing climatic conditions, for example by revising areas of high bushfire risk in the light of climate change projections (p.32). Bushfire threat is also noted as a reason for consideration of an urban growth boundary. This document also seeks to ensure that relevant biodiversity issues are addressed at the Structure Planning stage, anticipating changes to extent, quality and fire risks to vegetation under a changing climate (p.38). Bunbury, like Geraldton, notes the *State Policy on Natural Hazards and Disasters* which requires local government to have due regard to risks such as bushfire in making decisions on development proposals.

HIGH VELOCITY WIND

There is little discussion or policy in respect to land use planning and wind in either Geraldton or Bunbury. Interviews noted a concern about the potential effects of high winds on building, notably in Bunbury where the church steeple was destroyed by high winds in 2005, but any policy addressing such concern is likely to fall under the BCA and any additional structural requirements related to individual building and structures. The *Bunbury City Vision* notes that building design in the CBD should seek to avoid the creation of wind tunnels, with street development being at a human scale (City of Bunbury, 2007, p.34).

FLOODING/INTENSE RAINFALL

In Geraldton, the Greenough River poses a flood risk. The City seeks to control development within flood prone areas with a general presumption against development in flood prone areas and a requirement that all development proposals demonstrate that adequate protection from a 100 year ARI is in place (City of Geraldton-Greenough, 2010a, 5.13.1)

Bunbury has noted the potential of the Preston River to flood, and in constructing flood levees, requires 500 year ARI protection from a regional flood within the City of Bunbury. Local Planning policy prohibits development within 100m of the toe of the levee and there are strict controls on floor levels as indicated in a number of flood studies which have been undertaken in

the city. The planning scheme contains maps that may be used as the basis to refuse development proposals on flood prone land.

COASTAL

The Geraldton region has expanding coastal development, combined with low height above sea level, and a sandy shoreline, which makes it vulnerable to storm surge and in future, rising sea levels. The *BROC CCAP* seeks to identify locations most vulnerable to sea level rise and storm surge inundation and develop a long term plan for management that considers avoiding (e.g. setbacks from the coast); adapting (e.g. raising building and infrastructure heights); defending (e.g. beach stabilisation, nourishment, restoration, groynes) and retreat (e.g. purchasing land to move development back from the shoreline) (p.31). It further suggests development of a region-specific methodology for appropriate coastal setbacks (agreed on with developers and government), addressing concerns not currently covered by the State Coastal Planning Policy (p.32). The document that sets policy state wide stipulates coastal setbacks based on extreme storm risk and different types of coast morphology (e.g. sandy, rocky, mangroves etc). Bunbury is also subject to state wide coastal planning policy and has undertaken significant modelling work to estimate the potential effects of storm surge from a worst case scenario repeat of Cyclone Alby which caused extensive damage to South Western Australia in 1978.

SUMMARY

See Table 20 for a summary of the analysis of land use planning policy and plans for response to climatic factors for Geraldton and Bunbury. Western Australia has the most centrally controlled planning system of the three states studied. As a result, both analogue and target communities are subject to a range of policies that derive from climate related factors and which seek to regulate new development. That said, the regional tier of planning provides some significant examples, particularly in respect to water supply and distribution, where policy seems to be especially responsive to climatic factors. At present, this policy appears to take the form of directions within which detailed land use policy may be developed in future. A second notable aspect is the existence in the Target community, not only of well developed policy but also of recorded studies and data, which may be used to justify and enforce policy. In this respect it could be argued that the target community is in advance of the analogue in having a well developed policy informed by accurate data on climatic factors. It is also notable that the broad policy directions set out at WA state and regional level extend well beyond the formal preserve of land use planning as interpreted in the other two states under consideration. Thus there is significant overlap between land use planning, infrastructure, housing and building and ecosystem management policy in WA. In respect to land use planning it appears that climate has not been a significant driver of policy in the past, but there is ample evidence that this situation is changing as result primarily of a changing climate, which is increasing heat, drought and flood risk conditions.

Table 19 Analysis of integration of climate factors into land use planning policies, plans and processes for Geraldton and Bunbury

Geraldton – Bunbury					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Geraldton BROC CCAP</p> <ul style="list-style-type: none"> suggestions for coping with extreme heat including use of public facilities 	<p>Geraldton State Planning Policy 2.9 Water Resources</p> <ul style="list-style-type: none"> role of land use planning in managing water urban growth boundary based on water availability? <p>Greater Geraldton Regional Plan</p> <ul style="list-style-type: none"> water availability constrain on development 	<p>Geraldton State Planning Policy 3.7 planning for Bushfire protection</p> <p>Greater Geraldton Regional Plan</p> <ul style="list-style-type: none"> bushfire risk a constraint of development 	<p>Geraldton No evidence</p>	<p>Geraldton City of Geraldton Planning Scheme</p> <ul style="list-style-type: none"> Development should not take place in flood threatened areas unless 100 yr ARI protection is in place. 	<p>Geraldton State Coastal Planning policy BROC CCAP</p> <ul style="list-style-type: none"> Identify vulnerable locations and appropriate policy response.
<p>Bunbury Bunbury Local Planning Scheme</p> <ul style="list-style-type: none"> requirement for shade planting to reduce heat and aid water infiltration 	<p>Bunbury State Planning Policy 2.9 Water Resources</p> <ul style="list-style-type: none"> role of land use planning in managing water 	<p>Bunbury State Planning Policy 3.7 Planning for Bushfire protection</p>	<p>Bunbury Bunbury City Vision</p> <ul style="list-style-type: none"> avoid creation of wind tunnels in CBD development 	<p>Bunbury City of Bunbury Planning Scheme</p> <ul style="list-style-type: none"> 500 year ARI protection from regional flood in city 	<p>Bunbury State Coastal Planning Policy</p> <ul style="list-style-type: none"> significant modelling done on storm surge potential

4.3.6 Infrastructure

Section 7.4 of the WA State Planning Strategy covers Infrastructure (Western Australian Planning Commission, 2011a). The key principle is to facilitate strategic development by ensuring land use, transport and public utilities are mutually supportive, with the main emphasis being on transport systems and other strategic infrastructure (e.g. gas pipelines, electricity grid) to support economic and major resource development. However, the resilience of infrastructure to climate factors and risks is not mentioned.

At a regional level, the Mid-West Infrastructure Analysis is a key document, and the SWDC Strategic Plan contains a section on Infrastructure and Environment.

HEAT

The Australian Railroad Group (ARG) has highlighted the effect of heat on the WA grain rail network: 'Grain trains along the network cannot operate at certain times during summer because of heat restrictions', and 'speed restrictions along certain parts of the network also weighed on its performance'. The WA Government announced in May 2010 that \$80 million would be invested in the rail network (Rail Express, June 2010). This problem has also been highlighted by the Australian Rail Track Corporation Ltd (ARTC), which has instituted a programme of replacing wooden sleepers with concrete sleepers on the Sydney to Brisbane line. In addition, the CRC for Rail Innovation has established a project 'Track stability management to improve safety and track capacity', focusing on the effect of temperature changes on the stability of rail tracks – 'a significant safety and business risk to railways' (Centre for Research Centre (CRC) for Rail Innovation, 2011). However, further study is required to determine if differences in temperature have impacted differently on rail operations in the mid-west and south-west of Western Australia.

In relation to community infrastructure, the City of Geraldton-Greenough (CGG) places a high priority on identifying cool spaces (e.g. community centres, libraries, swimming pools) that have the capacity to expand in order to cater for increased community use as heat refuges. It also encourages more sporting events to be played indoors, not only to reduce irrigation needs but also heat exposure (AECOM Australia Pty. Ltd., 2010 p.34, 35).

In this regard, the CGG *Sporting Futures Report* (City of Geraldton Greenough 2010b) highlights a 'growing requirement from the major funding bodies for multi use facilities with co-location of some sporting groups and clubs'. There is much to gain from being in alignment with funding guidelines and perhaps even more to gain for sport in the region, once such synergistic benefits can be understood, appreciated and acted upon'. Although this policy is not driven by climatic factors, the council recognises (Interview, 17 February 2011) the risks posed by heat to sporting events and grounds and, in this regard, that sharing the provision and use of indoor sporting facilities provided additional benefits.

Within the Bunbury area, there was no evidence of heat related policies applying to infrastructure and community facilities.

DROUGHT

At a regional level, in its infrastructure analysis, the WA Planning Commission (2008) has highlighted the importance of water infrastructure, including potable supply and distribution, and alternative sources. This is a key requirement underpinning the resource driven growth in the Mid West and other regions. Major concerns were raised (Interviews with the Mid-West Development Commission, 17 February 2011 and the South-West Development Commission, 21 February 2011) about the availability of water to service major new industries, such as in the Geraldton or Collie areas. The drawdown of groundwater and aquifer sources by industry was seen to impact

not only upon water availability for communities and farming, but also upon the sensitive biodiversity.

The WAPC notes, as one of the key issues requiring attention, that water supply and associated infrastructure requirements for the hematite and magnetite projects is uncertain. In particular, magnetite is a lower grade ore that needs power and water for processing. The \$2 billion Karara Magnetite Project has applied for a 5 gigalitre water licence, about 80% of the available recharge in the subsection of the Parmelia Aquifer, which has created a clash between mining and farming interests. A local farmer asked, 'How do you calculate workout recharge in a dry environment where we are getting less rainfall. It's a known fact. The last 10 years at Mingenew the rainfall has dropped off considerably... like the rest of Western Australia' (ABC Lateline, 8 May 2011). A further issue is that, under WA law, water allocations are made on a first come, first served basis.

The Oakajee project, involving a deep water port and rail infrastructure serving iron ore and other mines in the Mid West, is another case in point. The Western Australian Planning Commission notes: 'the Oakajee site does not contain sufficient water supply to service the future port and industrial estate. Water would need to be imported from a major groundwater resource such as the Casuarina aquifer...' (Western Australia Planning Commission, 2008). A desalination plant is also being considered to serve the Oakajee project.

Similarly, the City of Geraldton-Greenough (CGG) recognises that business-as-usual approaches are inadequate to deal with rainfall decline, large industrial development and expansion in its population (see City of Geraldton-Greenough, 2010c). To illustrate the problem, the CGG described (Interview, 17 February 2011) the instance of the Town of Northampton running out of water, with water needing to be carted to provide the supply. A water supply pipe has since been installed.

The City acknowledges that reduced annual rainfall combined with increased extreme events affects the quality and amount of drinking water supplies. The city is actively planning for increases in storage and the use of alternative sources (groundwater, rainwater tanks, reuse or desalination), as well as reduced per capita use. Groundwater in the CGG is the major source of water for irrigation, industrial and commercial developments, agriculture and drinking water supply. The groundwater resource for drinking water supply for Geraldton-Greenough is located outside the municipality, to the south, managed by the Department of Water. The City utilises groundwater from local aquifers for non-potable uses, primarily for the irrigation of public open space. Groundwater meets around 70% of the City's water needs.

The council is responding to current challenges by negotiating with the Water Corporation to increase reuse of wastewater from its existing level of 50% to 100% by 2030; maintaining current groundwater allocation by negotiating with the Water Corporation and the Department of Water to ensure that the current public drinking water allocation of 18.5 GL per annum is not increased to the 27 GL per annum recommended by GHD (2007). Instead, the CGG is planning around efficiency and reuse targets, and possibly wave energy seawater, to augment supply. This is to ensure that reserves are not compromised by drought and that sufficient allocation is available for other water users, e.g. industrial and agricultural.

The CGG noted (Interview, 17 February 2011) that the above mentioned policy concerning indoor sports facilities had co-benefits not only related to heat but also water shortages. The council is also addressing the water shortage problem with a program to create sumps and wetlands in public reserves and harvesting water to maintain sports ovals.

Turning to Bunbury and the SW Region, it is apparent that, whilst some plans are in place to cope with water shortages, the experiences of the Mid West and CGG could provide valuable lessons.

The SWDC plans to have an effective water distribution and access plan in place to support the needs of the community, the environment and industry to at least 2025. By 2015-2020, it is

expected that South West communities will be effectively drought-proofed to meet forecast population growth (South West Development Commission 2010).

The South West is experiencing less recharge from rainfall reaching the groundwater system every year. At the same time, there has been an increase in the number of people living in the area, as well as in commerce and local industries. All rely on secure water supplies. Currently around 4000 industries, landowners and domestic bore users rely on the groundwater resources in the area (Department of Water (WA), 2010b).

Water issues have loomed large for the \$3.5 billion Perdaman Collie Urea Plant, which turns Collie coal into urea (fertiliser). The contingency options for water supply are an important issue being addressed due to the reliance of the supply strategy on surface water sources and the impacts of climate on the availability and security of surface water resources for the duration of the plant. Groundwater in the Upper Collie basin is fully allocated due to high demand from the coal-based industries, particularly power generation. Perdaman estimates that for the purposes of plant operation, an annual water license allocation of 12 GL per annum is required. To meet this demand, the company has applied to the Department of Water for a 5C surface water allocation from Wellington Dam, a surface water source approximately 35 km west of the proposed site. The Department of Water has, in principle, agreed to license Perdaman to extract 12 GL pa of water on the condition that the company develops a water strategy that identifies and addresses other water supply options and contingencies (GHD, 2009).

BUSHFIRE THREAT

The WAPC has produced a 'Planning for Bushfire Protection' tool. Whilst the CGG has a Bushfire Emergency Response Plan and issues safety advice to householders to mitigate the effect of bushfires (Safety First), there was no evidence of policies pertaining to infrastructure.

The City of Bunbury Annual Report 2009/2010 reveals that the City worked on the Bunbury Resilient Communities Project over the preceding 12 months to find innovative and improved ways to engage and consult with the Bunbury people to increase preparedness, awareness and actions so that everyone acknowledges their personal responsibility for their own safety and survival from disaster or significant infrastructure breakdown (City of Bunbury, 2010a).

HIGH VELOCITY WIND

The *WA Emergency Management Act, 2005* establishes a framework for managing emergencies of a large scale or catastrophic nature requiring a significant and co-ordinated response. In addition, *Australian Standard AS 3745-2010* deals with emergency planning of facilities.

On 16 May 2005, Bunbury was hit by a tornado which cut a 100m wide swathe of destruction through the city. Looking back, the Bunbury Herald noted (17 May 2011) that '*cars were beaten to a pulp by fallen trees and collapsed buildings, schools were closed, the central business district brought to a halt and drivers confused by the chaos on the roads*'. In addition, 'the Bunbury police station power went down with all outside communication cut'.

Whilst an Emergency Management Evacuation Plan has been created by the City of Bunbury to deal with bushfires, floods, severe weather and other events, there is no evidence of infrastructure specific requirements.



Figure 7 Looking Back: Aftermath of the Bunbury Tornado, 2007
(Photo: Bunbury Herald, 2011)

FLOODING/INTENSE RAINFALL

The *Stormwater Management Manual for Western Australia* (Department of Water (WA)) notes that stormwater management is unique in Western Australia, as both stormwater and groundwater may need to be managed concurrently.

In Western Australia, where there is a superficial aquifer, drainage channels can commonly include both stormwater from surface runoff and groundwater that has been deliberately intercepted by drains installed to manage seasonal peak groundwater levels.

The '*2029 & Beyond*' plan for the Greater Geraldton City Region promotes 'green infrastructure' as part of protection against flooding: 'living roofs, trees and soft landscape areas absorb rainfall; a network of street swales, retention basins, rivers and creeks can safely manage large volumes of water during times of heavy rainfall'. In addition, the *BROC Climate Change Adaptation Plan* (2010, p.36) requires that practical climatic advice and information is progressively integrated into local emergency management plans to ensure flood prone and storm surge risk areas are identified and managed appropriately (including possible construction of levee banks).

Stormwater management is of particular concern in the South West Region and Bunbury. Between Bunbury and Cape Naturaliste, nine short rivers and major creeks drain the Whicher Range and/or the Swan Coastal Plain and discharge into Geographe Bay. Many of the creek systems and lower reaches of the rivers have been either entirely or partially modified as part of artificial drainage systems to drain the very low-lying and now cleared Swan Coastal Plain, and thus enable its use for dairy farming and other forms of agriculture (Water Resource Centre, 1997).

The City of Bunbury has undertaken extensive flooding studies and established a Flood Management Strategy. This notes that the Preston River is flanked on both sides by levees, and the levee system was raised and strengthened after being breached in a major flood event in 1964. Whilst the levee system is of 'unknown structural integrity', it would contain – in the absence of failure or forced breach – a 100 year flood with 550 mm freeboard.

In an interview with the target council, concern was expressed that the flooding of the rivers converging upon Bunbury, coupled with heavy rainfall and storm surges, could have catastrophic effects on the city if all events occurred simultaneously (Interview, City of Bunbury, 21 February 2011).

COASTAL

The *WA State Planning Policy 2.6 - Coastal Planning* (2006: xxii) requires that new buildings and foreshore infrastructure on the coast be positioned to avoid risk of damage from coastal processes and, where possible, avoid the need for physical structures to protect development from potential damage caused by physical processes on the coast. It also requires that development in cyclone prone areas to the north of latitude 30 degrees (approximately north of Cervantes) 'should be set back from the foreshore to afford protection from the impact of cyclonic storms. The extent of the setback should be defined on a case-by-case basis.... The storm surge that accompanies coastal cyclones can inundate large areas at significant distance inland from the high-water mark. The setback should be defined with regard to the amount of existing foreshore protection (natural or man-made) and to local topography including waterways, as storm surge can induce back-flooding. Development should be set back from any areas that would potentially be inundated by the ocean during the passage of a Category 5 cyclone tracking to maximise its associated storm surge'.

Interviews (Northern Agricultural Catchment Council DATE March 2011) revealed that traditional defences are preferred in Geraldton, including more hard structures such as groynes and sea walls. Concern was expressed that such a strategy is expensive, requires maintenance and may cause erosion elsewhere. There was also concern about disruption to coastal processes and sand movement, and at reserve land being swapped for private development on the coast. However, the CGG (Interview, City of Geraldton-Greenough, 17 Feb. 2011) indicated its preference for new development to incorporate appropriate setbacks from the coast. The strategy is to move back from the coast, but this is not easy when the land is privately owned.

The *BROC CCAP* (2010) recommends that new recreational facilities along the coast be designed to be easily relocated (p.28) and that practical climate advice and information is progressively integrated into local emergency management plans to ensure that flood prone and storm surge risk areas are identified and managed appropriately (including possible construction of levee banks) (p.36).

The CGG aims are to understand coastal processes in the region, and use that knowledge to inform its coastal management priorities and practices (Northern Agricultural Catchment Council, Department of Planning and Geraldton Port Authority, 2010). As noted above, Bunbury is especially vulnerable to sea level rise and storm surges. The Department of Climate Change (2009, p.117-118) has pointed out that around 24 per cent of the existing housing stock in Bunbury is at risk of sea level rise, with the coast between Bunbury and Mandurah being most vulnerable to coastal erosion.

After the 1964 floods, Bunbury strengthened its coastal defences, primarily with the use of groynes, flood gates and the like (Interviews, City of Bunbury, 21 February 2011, and South West Development Commission, 21 February 2011).

SUMMARY

See Table 21 for a summary of the analysis of infrastructure policy and plans for response to climatic factors for Geraldton and Bunbury. Comparison of the analogue and target locations in Western Australia shows that there were discernible differences in policies, plans and practices in relation to heat and drought. However, an isolated example, Geraldton-Greenough, is promoting the shared use of indoor sports facilities, whereas this was not evident in Bunbury.

Whilst heat was an issue for rail operations in the WA wheat belt, further study is required to ascertain if there are regional differences.

The CGG is also responding to severe water shortages, and this was a critical issue for large industrial and mining developments in the Mid West. The South West, however, appears to be more at the long-term planning stage, although water issues have already loomed large e.g. Collie Urea Plant. Thus, it is possible for the target to learn from its northern analogue, as has already occurred in relation to agricultural practices where northern farmers travelled to the south to relay their knowledge and experience (Partners in Grain cited by Northern Agricultural Catchment Council, 2011a).

Whilst there were no discernible regional differences in policies and approaches to coastal infrastructure, the cost burden for local governments was a common concern.

Table 20 Analysis of integration of climate factors into infrastructure policies, plans and processes for Geraldton and Bunbury

Geraldton – Bunbury					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Geraldton</p> <ul style="list-style-type: none"> effect of heat on grain rail network highlighted by ARG CGG high priority to indentifying cool spaces, encouraging indoor sports <p>CGG Sporting Futures Report (2010)</p> <ul style="list-style-type: none"> co-location of sporting clubs, multi-use facilities co-benefit of increasing indoor space 	<p>Geraldton</p> <ul style="list-style-type: none"> Town of Northampton ran out of water, required carting. Pipe now installed. CGG planning for increases in water storage and alternative sources (e.g. wave energy seawater desalination) and reduced domestic per capita use: public drinking water allocation 18.5 GL CGG seeking to increase wastewater reuse from 50% to 100% by 2030 Mining and industry drawdown of groundwater creating conflicts with farmers and community (See Case Study in main report) 	<p>Geraldton CGG Bushfire Emergency Response Plan</p> <p>No evidence</p>	<p>Geraldton WA State Planning Policy 2.6 Coastal Planning</p> <ul style="list-style-type: none"> impact of cyclonic storms to be considered north of Latitude 30 (around Cervantes) 	<p>Geraldton WA Stormwater Management Manual (Dept. Of Water)</p> <ul style="list-style-type: none"> Stormwater and groundwater managed concurrently <p>CGG '2029 and Beyond' Plan</p> <ul style="list-style-type: none"> promotes green infrastructure as part protection against flooding 	<p>Geraldton</p> <ul style="list-style-type: none"> groynes & sea walls CGG aims to understand coastal processes <p>Coastal Processes & Coastal Management Options for Greys to Sunset Beach (2010)</p> <ul style="list-style-type: none"> preference for new development to be set back from coast (buffer)
<p>Bunbury</p> <p>No evidence</p>	<p>Bunbury</p> <ul style="list-style-type: none"> industry (e.g. proposed Collie Urea Plant) already affected by water shortages 	<p>Bunbury Bunbury Resilient Communities Project</p> <ul style="list-style-type: none"> to increase preparedness <p>City of Bunbury (2008): Bunbury Bush Fire Response Plan:</p> <p>no evidence</p>	<p>Bunbury Climate Change Adaptation Plan (BROC, 2010)</p> <ul style="list-style-type: none"> not among risks tornado struck Bunbury 2005, 'swathe of destruction' <p>City of Bunbury Emergency Management Evacuation Plan:</p> <p>No evidence</p>	<p>Bunbury WA Stormwater Management Manual (Department of Water)</p> <p>City of Bunbury Flood Management Strategy (2004)</p>	<p>Bunbury</p> <ul style="list-style-type: none"> vulnerable to sea level rise and storm surges,. risk of simultaneous event: cyclone, storm surge, heavy rainfall, flooding 24% housing stock vulnerable to sea level rise, also low lying light industrial land

4.3.7 Housing/Building

The construction requirements for buildings in Western Australia are dealt with by the BCA and this is used in conjunction with Residential Design Codes (R-Codes), which cover development control including the siting and design of residential developments.

HEAT

Geraldton and Bunbury are within the same climate zone 5, which means the deemed-to-satisfy provisions for energy efficiency regulations for buildings within the BCA are the same. However, for alternative energy efficiency solutions for houses using Nationwide House Energy Rating Scheme (NatHERS) software, TMY weather data is used. There are 69 sets of TMY weather data available for Australia allowing more specific design solutions to be made for energy efficiency. Geraldton (TMY dataset 12) has its own data set that differentiates it from Bunbury, which is within a zone that uses TMY dataset 54. Buildings other than housing e.g. hotels, offices, shops, medical facilities and education buildings as described in Volume 1 of the BCA, can also comply with the energy efficiency requirements via the alternative solution route using approved building energy analysis software with local climate data.

Local initiatives in the Geraldton analogue offer guidance for the target. These include the *BROC CCAP* (AECOM Australia Pty. Ltd., 2010), which aims to ensure that the City Building Energy Use Policy currently being developed includes recognition of potential increases in energy demand due to climate change; the Ferart Lifestyle Project for retrofitting existing houses; and the Local Planning Policy, *Towards Sustainable Residential Development* (City of Geraldton Greenough 2010c), which encourages certain types of plantings of specific aspects of building blocks to minimise solar radiation and local winds.

DROUGHT

Western Australia has additional requirements in the BCA for water efficiency relating to showerheads, taps, dual-flush toilets, outdoor private swimming pools or spas and distance from the hot water system to the furthest hot water outlet. However, these apply equally to the analogue and the target.

The recent Local Planning Policy, *Towards Sustainable Residential Development* (City of Geraldton Greenough 2010c) in Geraldton specifies more stringent water efficiency including reducing individual consumption to 100kL/person/annum, water conservation in development and landscaping, higher rated showerhead and taps, water saving measures in gardens and porous paving to allow infiltration of stormwater. This initiative could be an indicator for the target.

Linked to drought conditions is the incidence of dry land salinity and this can have an adverse effect on the footings and walls of buildings and infrastructure. Recently, the ABCB proposed a change to the BCA to take into account the effect of more widespread saline soils (ABCB, 2010). The forecast for the spread of dry land salinity in Australia by 2050 is noticeable in Western Australia, although this phenomenon is in a northwards direction from Bunbury/Perth towards Geraldton suggesting a reverse learning from target to analogue.

BUSHFIRE THREAT

In Bunbury, owners or occupiers of land must comply with Bush Fires Act 1954 to carry out fire prevention work. For land area of 2024 sq m or less, all flammable materials must be removed.

HIGH VELOCITY WIND

AS/NZS 1170.2:2011 Structural design actions Part 2: Wind actions referred to in the BCA places Geraldton in Region B and Bunbury in the more moderate Region 1A. This is a current difference which can be considered as an indicator for possible future climate changes for the target.

FLOODING/INTENSE RAINFALL

There are no specific requirements for avoiding flooding in the BCA at present. The ABCB has included a project on the 2010-11 work program for the development of a technical standard for housing and other low rise residential buildings in flood prone area.

Five minute rainfall intensities at 20 year and 100 year recurrence intervals for different locations are provided in Volume 2 Section 3.5 Roof and Wall Cladding. For Geraldton, the intensities are 132 mm/hr and 173 mm/hr, and for Bunbury are moderately higher at 148 mm/hr and 215 mm/hr. This difference could be of relevance to the target.

COASTAL

There are no specific requirements for avoiding flooding in the BCA. Sea level rise and its relevance to building development would be referred to under Land Use Planning.

SUMMARY

See Table 22 for a summary of the analysis of housing and building policy and plans for response to climatic factors for Geraldton and Bunbury. Geraldton and Bunbury are in the same BCA climate zone and the requirements for the deemed-to-satisfy requirements for energy efficiency are similar. However, for alternative solutions for energy efficiency in house design using NatHERS software, Geraldton and Bunbury have different weather data sets which enables discrimination down to the particular areas concerned. Furthermore, there are differences in the BCA relating to high velocity wind and intense rainfall, which may have implications for the target location given shifts in climate. Local Planning Policy in Geraldton highlights more stringent requirements for energy and water efficiency in buildings and gardens. These provide tangible knowledge for targets from the experience of the analogues.

Table 21 Analysis of integration of climate factors into housing and building policies, plans and processes for Geraldton and Bunbury

Geraldton – Bunbury					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Geraldton BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> similar deemed-to-satisfy provisions for energy efficiency but the alternative solutions route via thermal simulation software uses local meteorological datasets 	<p>Geraldton</p> <ul style="list-style-type: none"> WA has additional requirements in the BCA relating to water use in buildings. Geraldton specifies more stringent water efficiency. 	<p>Geraldton No evidence</p>	<p>Geraldton</p> <ul style="list-style-type: none"> BCA refers to AS/NZS 1170.2 with Geraldton in Region B. 	<p>Geraldton</p> <ul style="list-style-type: none"> BCA refers to rainfall intensities. 	<p>Geraldton No evidence</p>
<p>Bunbury BCA energy efficiency regulations.</p> <ul style="list-style-type: none"> similar deemed-to-satisfy provisions for energy efficiency but the alternative solutions route via thermal simulation software uses local meteorological datasets 	<p>Bunbury</p> <ul style="list-style-type: none"> WA has additional requirements in the BCA relating to water use in buildings. 	<p>Bunbury No evidence</p>	<p>Bunbury</p> <ul style="list-style-type: none"> BCA refers to AS/NZS 1170.2 with Geraldton in Region 1A. 	<p>Bunbury</p> <ul style="list-style-type: none"> BCA refers to rainfall intensities. 	<p>Bunbury No evidence</p>

4.2.4 Health Services

The *Health Act 1911* (WA), being old legislation, does not define a health service as such. However, the WA Department of Health (WADH) has developed a hierarchy of health services based on delivery at state wide, metropolitan or country level. The WADH takes a lead role on developing policy and plans to deliver health services in WA. While a *Draft Public Health Bill, 2008* has been prepared, it does not define the term 'health service' but, as its title implies, is concerned with public health and public health services. This draft bill requires the development of a state public health plan and local public health plans, with the latter to be developed by each local government. As both the analogue and target communities are regional communities outside of the Perth metropolitan area, health services to each are delivered by the WA Country Health Service – the Mid West Unit is located in Geraldton and the South West Unit is located in Bunbury. In addition to the Country Health Service, there is also an organisation known as Rural Health West which operates in both the Mid West Region and in the Greater Bunbury Region. In the Mid West Region, there are approximately 80 doctors, including private GPs, specialists and doctors employed by the hospital and the Aboriginal Medical Service. The South West Health Campus, located in Bunbury, is the South West Region's major health facility. It incorporates a public and a private hospital as well as a specialist medical centre.

According to section 17 of the *Emergency Management Regulations 2006*, the Fire and Emergency Services Authority of Western Australia (FESA) established by section 4 the *Fire and Emergency Services Authority of Western Australia Act 1998*, is the hazard management agency across the whole state for the emergency management aspects of preparedness and response to specified hazard to human health, to property and to the environment, including those related to weather events that may be linked to climate. In view of its human health focus, emergency services, in this study, are also considered to be health services provided to each community. While emergency management arrangements are in the control of the WA government and some emergency services are likely to be provided by volunteers, the ambulance service in WA is privately owned, resulting in fragmented governance (Interview, Western Australia Department of Health, 23 February 2011). Emergency management planning is a responsibility of local government and alliances such as BROC and the South West Local Government Emergency Management Alliance have been established in each region to share resources and information. Hence, similar arrangements for governance of health services exist in each of the analogue and target communities.

The following sections summarise policy noting any differences between the two communities.

HEAT

Most actions and advice to date that address heat demand on health services have been initiated at the state government level, although local government is responsible for implementing legislation such as monitoring food outlets to manage proliferation of food borne bacterial pathogens such as *Salmonella*, *Campylobacter* and *Listeria* spp. (Department of Health (WA), 2008, p.12). Evidence of the impact of heat on the provision of health services relates mainly to advice about food borne bacteria, UV exposure and potential for skin cancer, with advice about avoiding heat exposure during heat waves (Department of Health (WA) 2010a). The WA emergency management legislation (*Emergency Management Act, 2005*) is hazard driven. While heat wave has been recognised as a hazard in the Perth metropolitan area and a policy has been developed (Department of Health (WA), 2010a), the policy does not extend to the regional areas of WA although the policy notes that: '*Non-metropolitan Public Health Units should determine the alert levels for their respective areas based on historical temperatures*'. There has been a recent focus on the use of swimming pools and spas in hot weather (Department of Health (WA), n.d.). The lack of a specific heat-wave response plan in WA is seen as a limitation (p.18).

In the analogue community, *BROC CCAP* noted an action for councils to work with FESA, volunteer fire brigades and other stakeholders to develop a program to educate the community on climate change risks such as heat waves and the ways in which individuals can respond to them. A Wheatbelt Men's Health program has been established in the Mid West Region and promotes 'Talk to a Mate' philosophy to raise awareness of skin cancer. The *BROC* Councils have identified the need to review outdoor event schedules and strategies, aiming to minimise the number of events occurring in high heat wave risk periods, and to ensure adequate shading and drinking facilities are in place for those events that cannot be rescheduled (e.g. Australia Day) (AECOM Australia Pty. Ltd., 2010, p.34), or playing sporting activities indoors to reduce heat exposure (AECOM Australia Pty. Ltd., 2010, p.35). Other actions which have been identified by *BROC CCAP* include monitoring staff health and safety related to extreme weather events (e.g. heat waves), and revising work practices and safety policies in response to any increases (AECOM Australia Pty Ltd, 2010, p.35). The City of Geraldton-Greenough was also considering discounting swimming pool entry fees during heat waves although this was noted to be a low priority (AECOM Australia Pty Ltd, 2010, p.36).

While a skin cancer brochure was available at the local council offices in Bunbury and a cancer clinic had been established at Bunbury, the response noted in the Bunbury and South West Region was less evident. Hence, assuming that increases in average temperature due to climate change will be experienced in the target community, an opportunity presents itself to learn from action taken to minimise impacts of heat and heat wave in the Geraldton community and more broadly across the Mid West Region.

DROUGHT

At the state level in Western Australia, the Department of Health (2008) has identified potential impacts that drought may have on health services. These include the need for additional monitoring of alternative water supply quality such as grey-water, rainwater or stormwater, and the need to prevent disease from vectors such as mosquitoes if rainwater or stormwater storage increases, potentially hindering the effectiveness of mosquito management measures (Department of Health (WA), 2008, p.18). The impact of drought on the cost and availability of food has also been recognised, although action on development of drought tolerant plants and new cropping practices was still at a research stage and not evident in the analogue community (see CSIRO Urban Futures and Rural Futures, cited in Department of Health (WA), 2008).

In the analogue area, alternative water sources, including stormwater and wastewater, are being pursued. However, it has been noted that the effective management of stormwater is a required mechanism to reduce health risk from mosquitoes in the *Water Planning and Management Strategy* (City of Geraldton-Greenough, 2010c).

In the analogue community the North Eastern Agricultural Region's Wheat belt, a men's health program was implemented to investigate the impact of drought on the health of farmers. Within this program a project to improve preparedness for drought through off-farm employment and farm business flexibility was carried out. The aims of the project were to allow farmers to have flexible working arrangements, with work outside the farm (i.e. mining) which was aimed toward enhancing the mental health of farmers affected by drought conditions and low farm productivity (Interview, Department of Agriculture and Food, Northern Agricultural Region, 18 February 2011).

At a regional level, the *BROC CCAP* had recognised that drought was causing harder playing surfaces which increased potential for sporting injury. A response was to stage sporting activities indoors (AECOM Australia Pty. Ltd. 2010, p. 35).

In contrast, the drought conditions in the South West of WA had yet to present a noticeable impact on health services. There is opportunity for the South West to learn from the Mid West in respect to the types of health services being implemented to prevent farmers' mental health

impacts associated with drought, and to prevent mosquito borne diseases through use of stormwater during drought.

BUSHFIRE THREAT

In WA, councils work with FESA, volunteer fire brigades and other stakeholders to develop a program to educate the community on climate change risks such as bushfires and the ways in which individuals can respond to them (AECOM Australia Pty Ltd, 2010, p.34). In each community, councils had developed Bushfire Emergency Response Plans and used community volunteers. In the analogue community of Geraldton, the *BROC CCAP* noted that an early warning system, information distribution systems for times of high fire danger and regular system testing was in place (AECOM Australia Pty Ltd, 2010, p.34). The Geraldton community was employing staff to implement its bushfire emergency response obligations due to a deficit of volunteers (Interview, City of Geraldton-Greenough, 17 February 2011). In the target community of Bunbury, no such problems with available volunteers was evident, which may be a reflection of the larger population in the region compared to the analogue community. While annual property inspections take place, during 2009-10, the City of Bunbury Volunteer Bush Fire Brigade responded to 19 fires and assisted at fires at Bridgetown, Lancelin and Eneabba within the region (City of Bunbury, 2010a). Hence, while the target community is equipped to respond to the threat of bushfire, the current climate, future increases in heat and reduced rainfall may lead to increased bushfire occurrence, requiring a greater demand on emergency services.

HIGH VELOCITY WIND

The demand for health services due to high velocity wind relates to emergency response during cyclones or tornados, as well as the monitoring of air quality to minimise health impacts of dust and other airborne contaminants. According to the Department of Health (WA) (2008) the aged are considered to be most vulnerable to respiratory effects of reduced air quality.

Using records of the BoM cyclone observer office in the analogue community of Geraldton, tropical cyclones that have crossed within 100 km of Geraldton in the Mid West of WA (see Figure 8). Information is provided to residents about the cyclone warning system and storms in the area (brochure collected 17 February 2011). The greatest cyclone activity occurs in January, February and March. Tornadoes also occur in the area in winter (May to September). A tornado caused significant damage in Geraldton on 16th August 2005. In addition to the potential for cyclones and tornadoes, a real-time dust monitoring system has been developed (Interview, Mid-West Development Commission, 17 February 2011) to address the incidence of asthma from dust (Interview, City of Geraldton-Greenough, 17 February 2011).

In the target community of Bunbury, while high velocity wind events do occur, in May 1973, tropical cyclone Marcelle crossed the WA coast within 100 km of Bunbury (see Figure 9). Other than emergency response during events, there were no reports of extra demand on health services due to high velocity wind.

While the emergency response in each community appears to be similar, further research into the demand for health services to address increased dust and poorer air quality may present an opportunity for the target to learn from the analogue community.

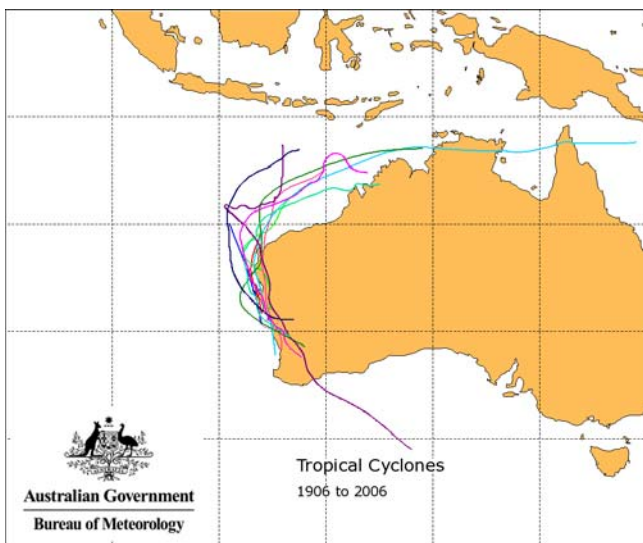


Figure 8 Tropical cyclones that have crossed within 100 km of Geraldton, WA – 1906 to 2006 (Source: Bureau of Meteorology 2011b)

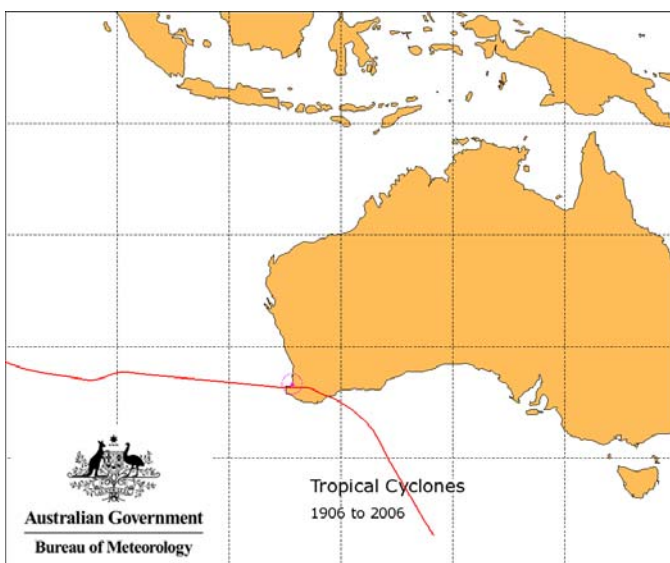


Figure 9 Tropical cyclones that have crossed within 100 km of Bunbury, WA – 1906 to 2006 (Source: Bureau of Meteorology 2011b)

FLOODING/INTENSE RAINFALL

The demand for health services related to flooding and intense rainfall mainly affects emergency services and increased monitoring of water quality to prevent waterborne diseases such as Cryptosporidiosis (Department of Health (WA), 2008, p.12). The Department of Health (2008) identify the aged as most vulnerable to waterborne diseases. At the state level, the current responses to intense rainfall and flooding include health warnings and a range of regulations and guidelines (Department of Health (WA), 2008, p.18). The incidence of vector borne diseases are also being monitored, particularly for human cases demonstrating exotic mosquito incursions (Department of Health (WA), 2008, p.18), a program also mentioned during the interview with

WADH staff (Interview, Department of Health (WA), 23 February 2011). However, controlling mosquitoes in most rural regions of WA was generally thought not to be possible because of the large area and inaccessibility of natural mosquito breeding habitat (Western Australian Country Health Service-Mid-West, 2011). Flooding may also block normal routes of emergency services and therefore cause delays in response.

In the analogue community, flooding results in warning people living and holidaying in the area to take care against mosquito bites. While the scale of mosquito management is acknowledged as a problem, the BROCC report (AECOM Pty Ltd, 2010, p. 34) proposed that councils should increase monitoring and treatment for mosquitoes after periods of heavy rain. In the target Bunbury area, flooding occurs frequently and significant infrastructure has been implemented to protect the community from floodwaters. The potential for mosquito-borne disease has also been identified as an issue for residents, and the City of Bunbury delivers a mosquito management program including surveys, monitoring, research, physical, chemical and biological controls and public education (City of Bunbury 2010a). The state wide focus on health services results in few differences between the two communities in respect to flooding.

COASTAL

Both communities are coastal, and both experience coastal events such as storm surges and storm tides. The demand on health services relates mainly to flooding and the ongoing management of vector borne diseases in coastal communities. Vulnerable communities are those people living within 3-5 kilometres of saltmarshes or brackish wetlands (i.e. estuaries and tidal rivers) and freshwater wetlands (Department of Health (WA) 2010b). In the analogue community, a Travel Clinic has been established by the Geraldton Medical Group which provides advice for preventing mosquito borne diseases such as Dengue fever in the coastal community. The coastal analogue community of Bunbury is within an area of high risk for breeding mosquitoes that may carry diseases (Interview, Western Australian Department of Health, 23 February 2011). While both analogue and target communities have requirements for health services that directly relate to the inundation of the coastal environment, there is little noticeable difference in the responses to impacts such as the need for mosquito management due to coastal climatic factors such as storm surges.

SUMMARY

See Table 23 for a summary of the analysis of health services policy and plans for response to climatic factors for Geraldton and Bunbury. The delivery of health services in both of the analogue and target areas is driven by the state government, with local programs being dictated to by state government policy. The main areas of difference where the target community may be able to learn from the impact of climatic factors on health services in the analogue community are in the health service responses to heat and drought. For heat, the main learning may come from the review of worker safety during heat events, while for drought, the mental health services provided to affected farmers and the increased management of mosquito borne disease associated with the management of stormwater may provide information.

Table 22 Analysis of integration of climate factors into health services policies, plans and processes for Geraldton and Bunbury

Geraldton – Bunbury					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Geraldton WADH (2008)</p> <ul style="list-style-type: none"> • food-borne disease - legislation, regulation and monitoring • lack of specific heat-wave response plan • rely on air conditioning and energy efficient buildings • aged considered more vulnerable • WA Emergency Management Act - Hazard driven; Heat wave not formally a hazard <p>Men's Health Day – Perenjori –</p> <ul style="list-style-type: none"> • 'Talk to a Mate' philosophy <p>BROC</p> <ul style="list-style-type: none"> • minimise number of events occurring in high heat wave risk periods, • ensure adequate shading and drinking facilities 	<p>Geraldton NEAR - Project 4</p> <ul style="list-style-type: none"> • prepare for drought - off farm employment and farm business flexibility. (i.e. mining) - mental health <p>BROC CCAP May 2010</p> <ul style="list-style-type: none"> • encourage sporting activities play indoors - reduce potential for injury due to harder surfaces –water restrictions <p>WADH (2008)</p> <ul style="list-style-type: none"> • state and regional water plans - water supply • increased use of grey-water - lack of licensing • downside - mosquito breeding hinders management measures • changes in cost and availability of food • research programs - Urban Futures and Rural Futures (CSIRO) 	<p>Geraldton BROC 2010</p> <ul style="list-style-type: none"> • continue to implement an early warning system and information distribution systems for times of high fire danger • undertake regular system testing <p>City of Geraldton-Greenough Bushfire Emergency Response Plan</p>	<p>Geraldton MWDC (& WADH)</p> <ul style="list-style-type: none"> • dust monitoring – real-time systems • asthma from dust • air quality management program • aged groups considered to be more vulnerable <p>BoM</p> <ul style="list-style-type: none"> • know your cyclone warning system <p>Stay Storm Safe</p> <ul style="list-style-type: none"> • advice to citizens 	<p>Geraldton WADH (2008)</p> <ul style="list-style-type: none"> • vector borne diseases • mosquito and human case surveillance for exotic mosquito incursions • warning to residents and tourists in northern and central WA to take care against mosquito bites <p>Dept Health (Interview 23 Feb 2011) -</p> <ul style="list-style-type: none"> • Looking at effect of 1 in 100 and 1 in 200 year events <p>BROC CCAP 2010</p> <ul style="list-style-type: none"> • Increase monitoring and treatment for mosquitoes after periods of heavy rain 	<p>Geraldton Department of Health Interview 23 Feb 2011</p> <ul style="list-style-type: none"> • storm events – more of these expected – coastal setbacks are important;
<p>Bunbury WADH (2008)</p> <ul style="list-style-type: none"> • food-borne disease - legislation, regulation and monitoring • more heat events in southwest leading to increased mortality • education program and awareness - to address UV exposure • adaptation through air conditioning and energy efficient buildings • aged groups and lower socio-economic levels vulnerable • lack of specific heat-wave response plan seen as a limitation 	<p>Bunbury WADH (2008)</p> <ul style="list-style-type: none"> • state and regional water plans - water supply • increased use of grey-water - lack of licensing • downside - mosquito breeding hinders management measures • changes in cost and availability of food • research Programs - Urban Futures and Rural Futures (CSIRO) 	<p>Bunbury Bunbury Bush Fire Response Plan/Brigade Response Plan</p> <ul style="list-style-type: none"> • Fire Hazard Mitigation - Annual property inspections • mandatory clearance specifications 	<p>Bunbury WADH (2008)</p> <ul style="list-style-type: none"> • Air quality management program • Aged groups considered to be more vulnerable 	<p>Bunbury City of Bunbury</p> <ul style="list-style-type: none"> • mosquito management program <p>City of Bunbury Environmental Health Emergency Management Support Plan 2004 Bunbury Risk Management Project,</p> <ul style="list-style-type: none"> • community consultation, identified 'floods' as presenting one of the most significant risks to the City. • call upon broad range of environmental health treatments - discrete emergencies. (e.g. sustained power or sewerage outages). • Repairing Flood Damaged Property 	<p>Bunbury City of Bunbury</p> <ul style="list-style-type: none"> • mosquito management program - surveys, monitoring and surveillance, research, physical, chemical and biological controls and public education

4.2.5 Ecosystem services

While the decision making body for natural resources management (NRM) in WA is the Ministerial Council (Western Australia State Natural Resource Management Board, 2010), in reality a number of state government agencies have responsibilities for managing natural resources to provide ecosystem services. Relevant NRM legislation includes: the *Wildlife Conservation Act 1950*; *Environmental Protection Act 1986*; *Planning and Development Act 2005*; *Conservation and Land Management Act 1984*; *Agriculture and Related Resources Act 1976*; and *Biosecurity and Agricultural Management Act 2007*. WA has six regional natural resource management groups. Regional communities are said to have an important role in identifying the natural assets that are important in their regions, to improve decisions and leverage non-government investment and volunteer action (Western Australia State Natural Resource Management Board, 2010).

In the analogue area, the Northern Agricultural Catchment Council (NACC) is the regional NRM body. NACC has identified some of the critical management issues for the area including water quality and quantity; control of introduced pests; soil quality and production levels and loss of biodiversity. Immediately prior to the research team's visit to Geraldton, NACC had been developing a proposal for a strategic project to develop corridors for wildlife to migrate naturally as an adaptation to changing climatic factors. NACC were also developing a seed bank of provenance species and proposed to gather stories from residents in rural communities in the region to understand the changes that people had been observing in ecosystem services, creating a database of personal experiences to leave as a legacy for current and future generations.

In the target Bunbury community, the South West Catchments Council (SWCC) is the community representative body that coordinates natural resource management (NRM) in the South West region. SWCC delivers on-ground projects targeting sustainable agriculture, protecting biodiversity, coastal environments, community knowledge, skills and engagement. The South West Development Commission (SWDC) has also identified a number of ecosystem services which were being affected by climatic factors in the region (Interview, South West Development Commission, 21 February 2011), including pollination of stone fruit (Manjimup) and grapes (Margaret River); lobster breeding cycles and wild catches.

In the following sections, the effect of specific climatic factors on the policies and programs to provide ecosystem services in each of the analogue and target communities are compared and differences noted.

HEAT

The DAF states that there has already been an observed increase in average annual temperatures over the past 30 years in WA (Department of Agriculture and Food, 2006). Hence, it is expected that policies and programs to maintain, protect or enhance ecosystem services in both communities may include the effect of increased temperature.

In the analogue Geraldton area, the Northern Agricultural Region (NAR) is stated to be one of the most vulnerable regions in the world to rising temperatures, reducing agriculture returns and devastating the biodiversity and local ecology. In 1999, the *Geraldton Region Plan* noted that native vegetation reflects the geomorphological pattern, the hot dry climatic conditions and rainfall distribution. Policy responses to heat, noted in the analogue community, include applying mulch in parks and gardens to reduce evaporation, which may also address drought (AECOM Australia Pty. Ltd., 2010 p. 29) and ensuring that 'Green' infrastructure is used to provide services which clean and cool the air, water and soil (City of Geraldton-Greenough n.d.e).

In the target community, while the effect of increased temperature was noted in a comment from the SWDC that viticulture had problems in hitting low temperature points critical for stages of

growth (Interview, South West Development Commission, 21 February 2011), no policy response was apparent.

While it was expected that policies and plans to protect ecosystem services may have already responded to increases in heat, the main evidence of action on the ground was in the analogue community. Therefore, the target community may be able to learn from the actions of the analogue to respond to heat, although the noted responses appear to be minor, and perhaps reflect a response to water shortage which is discussed in the following section.

DROUGHT

Examples of the impact of drought on ecosystem services were more extensive than the response to increasing heat. In WA, communities are more reliant on groundwater systems than in other states in this study. Groundwater systems are recharged through annual rainfall events due to the sandy nature of soils in both the analogue and target coastal communities. Department of Water (WA) DoW has assessed potential future demand for water from 2008 to 2030 in 19 water demand regions across the state using a purpose-built Demand Scenario Modelling Tool (DSMT). The Water Corporation (WA's state owned water utility) has undertaken a 'Security through Diversity' initiative which is developing a broader range of new water sources to secure water supplies, even in times of drought. There has been a focus on reducing water consumption and increasing efficiency in both areas. The Department of Agriculture and Food (DAF) has established a Dry Season Advisory Committee (DSAC) to assist farmers and rural communities adversely affected by the dry seasonal conditions. DAF is also using statistical models to produce timely forecasts of rainfall for the agricultural growing season in the south-west of WA which extends up to Northampton, north of Geraldton, in the Mid West. Hence there is a strong state government focus on addressing the impact of drought on ecosystem services, particularly related to agricultural productivity.

Specific policy responses to drought in the analogue community include a water allocation plan for the Arrowsmith Groundwater area (Department of Water (WA), 2010a) and a proposed Mid West Regional water plan. The DoW water allocation plans are required to balance current uses and future demand (from competing industry), while maintaining water-dependent ecosystems and the water resource. The *BROC CCAP* commits to continuing the implementation of the *Better Urban Water Management Strategy* which is required under *State Planning Policy 2.9 Water Resources* (AECOM Australia Pty. Ltd., 2010 p. 34). The CGG obtains its water supply from outside its council boundaries. To ensure that CGG community can grow but remain within its water allocation, CGG has submitted a *Water Conservation Plan (Water efficiency in public open space irrigation)* to DoW. According to CGG, feedback from DoW was that this plan was the benchmark for WA. An *Airport Water Efficiency Management Plan* had also been implemented which required a 15% reduction in water consumption at the Geraldton Airport by July 2011 (City of Geraldton-Greenough, 2010d)

The North East Agricultural Region (NEAR), a part of the NAR, had a long term plan to build resilience in the farming community. This action was triggered by a 5 inch (125mm) rainfall decline experienced in main growing areas, with 2006 and 2007 the driest and 3rd driest years on record. DAF is also studying social, economic and environmental factors that have helped farms in the NEAR area to survive the drought unscathed. DAF has implemented two projects which relate to productivity and drought. One focuses on off farm employment, the other focuses on developing production and/or business systems that help growers mitigate seasonal variability. NACC have also provided advice to farmers in the NAR along the coast, where pale deep sands predominate. Advice relates to planting perennial pastures instead of annual pasture crops, and how to manage grazing of perennial pasture crops during summer to ensure that seed is viable. Discussion with the DAF Agricultural Resource Risk Manager in Geraldton revealed that 75% of farmers surveyed in the NAR were willing to permanently revegetate their unproductive soils (Interview, Department of Agriculture and Food, Northern Agricultural Region,

18 February 2011). DAF also provided landholders with information such as soil maps and wheat yields.

While native vegetation in the analogue community reflects the geomorphological pattern, the hot, dry climatic conditions and rainfall distribution, the *Geraldton Regional Flora and Vegetation Survey* (Department of Planning and Ecoscape (Australia) Pty. Ltd., 2010) has concluded that recent regional drought conditions have resulted in shrub and tree deaths and loss of vigour in some areas. The vegetation condition was 'downgraded' as a result of drought rather than disturbance (Department of Planning and Ecoscape (Australia) Pty. Ltd. 2010, p. 42). At Northampton in CGG area, trees died from drought (Interview, City of Geraldton-Greenough, 17 February 2011). CGG developed Street Tree Management Specifications to require watering all new street trees including those planted by request of owners/occupiers until the trees were established (approximately 2 years). CGG was also encouraging property owners and occupiers to water newly planted street trees during the establishment period and writing to residents soon after the trees are planted to request this assistance. CGG were also adopting appropriate practices of pre- and post-planting care to ensure the survival of all trees planted. A water sensitive urban design (WSUD) focus in transport corridors, together with the use of salt resistant grass species, was also being promoted (Interview, City of Geraldton-Greenough, 17 February 2011).

Similarly, in the target Bunbury area, a significant decrease in average rainfall between May and October was observed during the past 30 years (DoW). A 50% decline in stream-flow since 1975 was observed, triggering research into water use dynamics (Interview 3, Department of Environment and Conservation, 23 February 2011). The response to this reduction in rainfall was to shift water harvesting from surface catchment to groundwater to desalination (marine resources). Similar to the analogue area, licensing of groundwater abstraction is used as a sustainable management tool. However, groundwater drawdown was having consequences for forest biodiversity with mass die off of Banksia Woodland noted in the Gngangara Mound. The *Bunbury City Vision Strategy* (City of Bunbury 2007, p. 13) notes that more knowledge of the sustainable yield from the Yarragadee aquifer is needed as well as more efficient use of water resources through WSUD, and the use of drought tolerant (endemic species) vegetation in gardens and public places. The City of Bunbury (2010a) notes that: a *Local Planning Strategy for Environmental Assets and Natural Resources* is being prepared to replace the outdated *Bunbury Sustainability Strategy*; that native seedlings had been planted and a dieback management plan for Manea Park was implemented.

In the target community, the presence of a superficial aquifer that caused flooding, particularly around Busselton, the construction of drainage channels has occurred. These channels commonly carry both stormwater from surface runoff and groundwater that has been deliberately intercepted by these drains. Hence, in the target community, the potential use of stormwater may be affected by its combination with groundwater. The impact of drought on the Geographe Bay Coastal Catchment (GBCC,) which is part of the SWCC area, resulted in a land capability assessment for managing the impact of land use change on scarce water resources (Acacia Springs Environmental et. al., 2005). In the Margaret River area of the South West region, while vineyards that regularly produced a high value crop were still being irrigated, small growers relying on dams experienced lack of water during the recent drought (Interview, South West Development Commission, 21 February 2011). Means to conserve water such as trials using Aquatain® polymers on the dams around vineyards in the Great Southern area were being explored (Department of Agriculture and Food n.d.). SWDC noted that the sustainable yield of forest timber was revised downward by 10% due to lower rates of growth, mainly as a result of lack of water (Interview, South West Development Commission, 21 February 2011). The dairy industry along the wheat belt had also been experiencing reduced gross margins per hectare (Interview, South West Development Commission, 21 February 2011). Anecdotal reports of white corellas being seen near Bunbury were also thought to be connected to drier conditions in the NAR and Carnarvon (Interview, South West Development Commission, 21 February 2011).

While drought has been experienced by both communities, the target community may be able to prepare for future change by learning from the analogue community through initiatives such as that described in the following excerpt provided by NACC:

From the north to the south to share experiences on handling dry seasons - two farmers hopped in their car and drove close to 600km to visit southern farmers and talk about managing dry seasons using their own experiences. They were joined by a Binu farmer, and DAFWA officer from Geraldton. About 70 farmers came along to hear their pearls of wisdom (Partners in Grain cited by Northern Agricultural Catchment Council, 2011).

BUSHFIRE THREAT

The response to the threat of bushfire on ecosystem services manifests itself in actions to prevent bushfires in areas where urban communities, farming enterprises or habitat may be adversely affected. In areas of native vegetation, the focus is on management, particularly where fire dependent species predominate. At the state level, the Department of Environment and Conservation (WA) (DEC) notes the need to research ecosystem functions to understand plant communities and the impact of fire regimes (Interview 3, Department of Environment and Conservation, 23 February 2011).

In the analogue community, the CGG requires landowners in its jurisdiction to manage land to prevent bushfires and ensure firebreaks. CGG and FESA issue advice about bushfires including road closures. At the regional level in the Mid West, DEC is the hazard management authority for rural fire and allows bushland to be burnt (e.g. 9 December 2009, fire burnt 2000 hectares at Moonyoonooka east of Geraldton; 1-2 March 2010, a number of bushfires burned through a total of almost 40,000 hectares of bushland near Enneaba, Kalbarri and Northampton in the Mid West region). While fires force highway closures and strand holiday-makers and evacuation of coastal fishing shacks and camping grounds (ABC 2010a), the regeneration in the country is said to provide a safe area for about 25 years (ABC, 2010b). *BROC CCAP* identified the need to ensure that relevant biodiversity issues are addressed, anticipating changes to fire risks to vegetation (AECOM Pty. Ltd. 2010, p.38).

In the target area, the City of Bunbury similarly ensures that landowners comply with the mandatory instructions to annually reduce the risks of bushfire spreading. The prescriptive nature of notices is reliant on the area of land in private ownership and land use. During a visit to the Bunbury and Busselton region by a research team member, evidence of recent bushfire at the Cape Naturaliste Lighthouse reserve was observed, with native plants regenerating and growing vigorously. However, in the Margaret River area, the focus was on preventing bushfire due to the presence of vineyard enterprises.

While minor differences were noted in the instructions to landowners in response to bushfire threat, both communities acknowledged the impact of bushfire on ecosystem services. The increased risk of bushfire may also be as a result of increased heat, periods of drought and higher velocity wind (which is discussed in the next section) hence, policies and programs in each area that manage the impacts of these other climatic factors on ecosystem services may also affect the extent and severity of bushfire impact on ecosystem services in each community. Further work would be needed to compare these combinations of factors. Of note is the extensive area of native vegetation in the analogue community that has been affected by bushfire events in the recent years and whether a similar outcome would be an acceptable policy response in the South West region of WA. Assuming that land use and ecosystem services in the South West change to reflect more the current Mid West analogue case, future policy to manage impacts of bushfire may also, in time, come to resemble that currently implemented in the Mid West region. The higher population and more diverse land use in the target area influences the policy response in that community compared to that in the analogue community.

HIGH VELOCITY WIND

The policy response to the impact of high velocity wind on ecosystem services in both of the WA cases relates mainly to minimising damage to agricultural land through wind erosion. One of the main priorities of the federal government's Caring for our Country land management program, and where funding is directed, is reducing the impacts of wind erosion on agricultural productivity. Hence, at the state level, DAF implement programs providing advice to landholders about mechanisms such as maintaining an adequate, stable cover of stubble on land to reduce wind erosion (Carter, 2007). DAF provide guidelines on impacts of wind at various wind speeds, report erosion threat, record the number of hours of wind speeds greater than 29 km/hr for sites in agricultural regions, and make this data available online. DAF also provide advice about grazing days and stocking rates.

In the analogue area, NACC assist farmers to plant perennial pasture, and promote vegetation management and revegetation to reduce wind erosion (Interview, Northern Agricultural Catchments Council, 18 February 2011). DAF noted, however, that even the best farmers with innovative practices had suffered erosion and that the farming system had caused this situation (Interview, Department of Agriculture and Food, Northern Agricultural Region, 18 February 2011).

In the target community, the SWCC funded 21 projects in the 18 months to March 2011 to address wind erosion – focused on planting oil mallee seedlings; perennial pastures; saltbush seedlings; other tree/shrub seedlings as well as erect⁶ fencing and set up watering points (South West Catchments Council 2011a). SWCC also funded trials of stubble mulching to minimise the risk of soil erosion and subsequent top soil. The outcomes of the trial were shared with other landholders and NRM Officers, to expand the range of options available to combat wind erosion in the South West (South West Catchments Council 2011b). DAF noted that increased wind speed affected the performance of trials using Aquatain® to reduce evaporation from dams around vineyards. Polymers such as Aquatain® are said to be more effective when used in conjunction with wind breaks. DAF provide advice on the appropriate tree and plant species to use for windbreaks, stating that those with a commercial crop or with a nature conservation value are preferable in the Wheatbelt of WA.

The focus of both the analogue and target communities is on the wind erosion aspect of high wind velocity and the impact that this has on agricultural land. Hence, there is little difference noted in the responses of each community in managing the impacts of high velocity wind on ecosystem services.

FLOODING/INTENSE RAINFALL

The response to impacts of flooding and intense rainfall on ecosystem services focuses mainly on pollution prevention resulting from the use of floodplains and riparian zones for agricultural or horticultural production or reduced income from floodplains used for light industrial purposes. Flooding and intense rainfall have localised impacts and, as stormwater management is a local government responsibility, flood management tends to fall mainly on local government to address. Pollution prevention and planning of new development and subdivision, however, are state government responsibilities in WA.

In the analogue community, at the regional level, DAF have noted that horticulture uses floodplains for vegetable growing and that policies have been developed which determine the level of reinstatement and soil replacement to pre-flood levels. The use of permanent pastures was noted to reduce the impact of flooding (Interview, Department of Agriculture and Food, Northern Agricultural Region, 18 February 2011). The *Geraldton Regional Flora and Vegetation Survey* noted that many of the areas with high weed cover are associated with riparian areas,

where weed cover is usually the result of a combination of fertile soil favouring weed colonisation, frequent or historic grazing (as riparian areas provide the best grazing land), and frequent disturbance from floods and stock trampling (Department of Planning and Ecoscape (Australia) Pty. Ltd., 2010).

In the CGG area, local and regional flooding from storm events had been noted (see City of Geraldton-Greenough, n.d.d). Protection against flooding was noted as being provided by living roofs, trees and soft landscape areas which absorb rainfall as well as by a network of street swales, retention basins, rivers and creeks which can safely manage large volumes of water during times of heavy rainfall. Hence, implementing WSUD principles enabled improved flood management. However, during flood events in the analogue area in late summer (February and March 2011), public health warnings and instructions were issued to avoid contact with water in the Chapman and Greenough Rivers and the coastal areas where the rivers discharged due to high levels of pollution. The services provided by the coastal ecosystems for recreation and tourism were therefore adversely affected.

As previously discussed, in the target area, drainage channels carry stormwater from surface runoff and peak levels of groundwater. In 1963-64, flooding inundated East Bunbury and the response was to drain Swampland and install floodgates (Interview, South-West Development Commission, 21 February 2011). Many of the creek systems and lower reaches of the rivers have been either entirely or partially modified as part of artificial drainage systems to drain the very low-lying, and now cleared, Swan Coastal Plain and thus enable its use for dairy farming and other forms of agriculture (Waters and River Commission, 1997). SWCC state that approximately 96% of the original wetlands within Geographe Bay have been lost or substantially modified and that the catchment's waterways are showing signs of stress. To reduce this pressure, SWCC has recently funded local landowners to install two new stock crossings on their properties, crossing the Vasse and Carbanup Rivers, to reduce the nutrients flowing into Geographe Bay.

Box 5 Approaches to Dealing with Intense Rainfall and Flooding

BOX 6. Approaches to dealing with intense rainfall and flooding

In the analogue community, Geraldton, the policy and engineering response to high rainfall and flooding events is based on slowing down runoff flows, using living roofs, trees and soft landscape areas, street swales, retention basins and natural watercourses. Inundation of floodplains is used to replenish arable and grazing land. By contrast, the target community, Bunbury, has installed land drains which take superficial groundwater and stormwater from the flooded area as quickly as possible to minimise flooding risk. As a result, the riverine/wetland ecosystems in the target are less able to deliver treatment of floodwater, which may impact on coastal ecosystems as water is discharged to the ocean. These different responses to a similar problem may result from differing local conditions in respect to topography and location of urban development. They suggest that future policy should seek to minimise development on floodplains, since this necessitates rapid removal of floodwaters, which can have harmful downstream effects .



Photo courtesy UK EPA



Photo courtesy Government of Victoria

In 2008, the Department of Water commissioned to undertake a land based LiDAR survey of 7000km² of the Swan Coastal Plain (Fugro Spatial Solutions cited in Department of Planning n.d.) resulting in a digital terrain model used to determine the patterns of flooding, groundwater/surface water interaction and ecological systems in the target area. Although the levee bank height at Bunbury has been increased concern was expressed by SWDC that this response does not address the underlying issues of why flooding may occur. SWDC note that

flooding is expected in the light industrial land on the coastal plains due to infill development in these areas.

Flooding in both communities has been experienced in the past. The reliance on ecosystem services to manage impacts of flooding in each community, however, is different. While the analogue community relies on flooding regionally to replenish floodplains for horticultural use and animal grazing, the target area has a high groundwater table and has installed drains to take superficial groundwater and stormwater from the area as quickly as possible to minimise the extent of areas affected by flooding. The presence of drains has allowed the target community to develop the floodplains with permanent structures and infrastructure, while the floodplains in the analogue community have less permanent structures. While coastal ecosystems in each case appear to be affected by pollutants carried in floodwaters, the terrestrial based and riverine/wetland ecosystems in the target community are less able to deliver services which treat floodwaters, potentially resulting in increased pollution of coastal ecosystems than would be the case if drains had not been installed. Thus different services are being provided by the floodplain ecosystems in each case.

COASTAL

At the state level, a policy has been in place for many years to maintain a coastal protection zone of at least 300m all along the WA coast. This coastal buffer provides protection for communities from coastal climatic factors. The Department of Transport (DoT) also collects data from 28 tide gauges from Esperance to Wyndham and has 100 years of local sea level variation records along the WA coast.

In the analogue area, the policy response is based on land use planning and the work of NACC, which has prepared a Coastal Monitoring Program Manual. Working with CGG, NACC have created clearly signed designated photo points along the coast. This program uses community participants to monitor photo points at beaches along the coast, taking photographs and reporting details. Research is also addressing coastal processes and coastal management options for Greys to Sunset Beach (Northern Agricultural Catchment Council, Department of Planning and Geraldton Port Authority 2010). Aims are to understand coastal processes in the region, including the movement of sand northward, and use that knowledge to inform the coastal management priorities and practices of CGG (Interview, City of Geraldton-Greenough, 17 February 2011).

In the target area, the SWCC employs a Coastal facilitator and volunteer coast care groups operate in the region. The Geographe Bay and Cape to Cape coastal areas of the South West region have also received significant attention from researchers and from federally funded coastal protection programs.

While there is a state wide approach to the protection of the coastal zone in WA, the analogue community's approach to ensuring that coastal ecosystem services are maintained, may provide knowledge for the target community.

SUMMARY

See Tables 24 for a summary of the analysis of ecosystem services policies and plans for response to climatic factors for Geraldton and Bunbury. The policies and plans to protect ecosystem services from the impacts of climatic factors are generally influenced by state led approaches, but have been adapted to regional variations due to geological and climatic variability from the analogue in the Mid West to the target in the South West. From the analysis undertaken, the analogue may provide knowledge to the target community regarding responses to heat and drought, particularly for agricultural productivity, and in the local approach to more

community based coastal monitoring as a response to coastal erosion arising from storm surges along beaches.

Table 23 Analysis of integration of climate factors into ecosystem services policies, plans and processes for Geraldton and Bunbury

Geraldton - Bunbury					
Heat	Drought	Bushfire threat	High velocity wind	Flooding/intense rainfall	Coastal
<p>Geraldton Geraldton Region Plan 1999</p> <ul style="list-style-type: none"> vegetation is typically sand heath or low scrub. <p>BROC CCAP 2010</p> <ul style="list-style-type: none"> current practice - mulch parks and gardens to reduce evaporation and stabilise topsoil <p>DEC</p> <ul style="list-style-type: none"> focus is on conservation biology and species recovery 	<p>Geraldton Arrowsmith Groundwater Allocation Plan 2010</p> <ul style="list-style-type: none"> allocation and licensing of groundwater <p>Dept of Water – Water Futures for Western Australia 2008-2030 -Modelling</p> <p>DAF - Statistical models - timely forecasts of rainfall for agricultural growing season</p> <p>Dry Season Advisory Committee (DSAC) -assists farmers and rural communities</p> <p>DEC - Northern Sand Plain - research on ecosystem functions - understanding plant communities and water use dynamics</p> <p>Better Urban Water Management Strategy</p> <p>NEAR- Project 5 - Developing production and/or business systems that help growers mitigate seasonal variability.</p> <p>NACC (2011) cites- Partners in Grain -'From the north to the south to share experiences on handling dry seasons'</p> <p>Geraldton Regional Flora and Vegetation Survey Recent regional drought conditions - shrub and tree deaths and loss of vigour –</p> <p>CGG (Interview 17 Feb 2011) - Community and farmer concerns re Karara mining water allocation. No water left, full allocation, ground water declining. Northampton – trees died from drought.</p> <ul style="list-style-type: none"> Street Tree Management Specifications WSUD focus in transport corridors – allocation review – salt resistant grass species <p>MWDC (Interview 17 Feb 2011) Agricultural Resource Risk Manager operates in NAR</p>	<p>Geraldton BROC CCAP 2010</p> <ul style="list-style-type: none"> ensure relevant biodiversity issues are addressed at the Structure Planning stage <p>DAF</p> <ul style="list-style-type: none"> 'It's going to be a long dry summer! ACT NOW!' advice to farmers <p>CGG email response</p> <ul style="list-style-type: none"> bushfire intensity in Chapman River Wildlife Corridor 	<p>Geraldton DAF Farmnote No. 67/2002 (Rev Oct 2007)</p> <ul style="list-style-type: none"> advice to landholders - stubble coverage to reduce wind erosion - Minimise tillage Reports wind speeds Grazing days and stocking rates advice. <p>NACC, - Current projects address wind erosion</p> <p>DAF (Interview 18 Feb 2011</p> <ul style="list-style-type: none"> best farmers have suffered erosion as well <p>CGG email response</p> <ul style="list-style-type: none"> top soil dust from agricultural areas 	<p>Geraldton Geraldton Regional Flora and Vegetation Survey</p> <ul style="list-style-type: none"> many of the areas with high weed cover – due in part to flooding - <p>DAF - criteria set for soil replacement program</p> <p>CGG 2029 and beyond</p> <ul style="list-style-type: none"> living roofs, trees and soft landscape areas absorb rainfall; WSUD 	<p>Geraldton Coastal processes and coastal management options for Greys to Sunset Beach (2010)</p> <ul style="list-style-type: none"> NACC - Participants adopt beaches along Geraldton Coastline - monitor by taking Photographs & reporting details. DoT - data from 28 tide gauges - Esperance - Wyndham – local variations in sea level over the past century
<p>Bunbury DAF (2006) Climate change, vulnerability and adaptation for south west Western Australia 1970 to 2006</p> <ul style="list-style-type: none"> past 30 years higher ave annual temp <p>City of Bunbury Town Planning Scheme No. 7 –</p> <ul style="list-style-type: none"> not less than 90% indigenous trees and shrubs - reduce radiant heat 	<p>Bunbury DoW - Stormwater Management Manual for WA</p> <ul style="list-style-type: none"> Water Futures for Western Australia 2008-2030 -Modelling <p>Water Corporation -'Security through Diversity' initiative - a broader range of new water sources developed to secure water supplies, even in times of drought</p> <p>DAF - Statistical models - timely forecasts of rainfall for agricultural growing season</p> <ul style="list-style-type: none"> Horticulture - Trials using Aquatain® on dams around vineyards <p>Dry Season Advisory Committee (DSAC) - assists farmers and rural communities</p> <p>DEC Colin Yates Interview 23 February 2011 - Groundwater drawdown in SW WA has consequences for forest biodiversity; Gnangara Mound – mass die off of Banksia Woodland; 50% decline in streamflow since 1975; research into water use dynamics</p> <p>Geographe Bay Coastal Catchment -Land Capability Assessment for Managing the Impact of Land Use Change on Water Resources</p> <ul style="list-style-type: none"> also Busselton Capel Groundwater area - in area Bunbury to Cape Naturaliste - proclaimed under the Rights in Water and Irrigation Act 1914. <p>SWDC Interview 21 Feb 2011 – Forest timber sustainable yield has been revised downward (10% built into management plan) – due to lower rates of growth – mainly due to lack of water</p>	<p>Bunbury City of Bunbury - First and Final Fire Notice 2010/2011. –</p> <ul style="list-style-type: none"> owners or occupiers of land - must comply with Bush Fires Act 1954 to carry out fire prevention work 	<p>Bunbury DAF Farmnote No. 67/2002 (Rev Oct 2007)</p> <ul style="list-style-type: none"> advice to landholders about stubble coverage -reduce wind erosion - Minimise tillage atates wind speeds grazing days and stocking rates advice. <p>SWCC - funded 21 on ground projects</p> <ul style="list-style-type: none"> wind erosion - 119,000 oil mallee seedlings; 509 ha of perennial pastures; 128,100 saltbush seedlings; 12,800 other tree/shrub seedlings; funded 5.9 km fencing; and 4 watering points 	<p>Bunbury DoW</p> <ul style="list-style-type: none"> Stormwater Management Manual for WA Drainage channels <p>DoW - Terrestrial LiDAR - 2008</p> <ul style="list-style-type: none"> Land based LiDAR survey of 7000km² Swan Coastal Plain. land use - dairy farming & other agriculture need to protect and enhance riparian corridors - 	<p>Bunbury SWCC - Seminar on shoreline protection DoT</p> <ul style="list-style-type: none"> data from 28 tide gauges - Esperance - Wyndham – local variations in sea level over the past century

4.4 LIST OF REFERENCES – WESTERN AUSTRALIA

Table 24 Summary of references for Western Australian pairing

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
STATE							
Carter, D. 2007. <i>The amount of stubble needed to reduce wind erosion</i> , Farmnote 67/2002 reviewed 2007, Department of Agriculture and Food, Government of Western Australia, Perth. http://www.agric.wa.gov.au/objtwr/imported_assets/content/lwe/land/erosion/fn067_2002.pdf	Eco				#		
Department of Agriculture and Food (n.d.) 'Dry Season – Horticulture', Frequently asked questions. http://www.agric.wa.gov.au/objtwr/imported_assets/content/lwe/cli/adv/dry_season_frequently_asked_questions_horticulture.pdf	Eco		#				
Department of Fisheries 2010. <i>A Sea Change for Aquatic Sustainability – Framework for a New Act of Parliament to replace the Fish Resources Management Act 1994</i> . Fisheries Occasional Publication No. 79, Government of Western Australia, Perth http://www.fish.wa.gov.au/docs/op/op079/fop79.pdf	Eco						#
Department of Health (WA), (n.d.), Pool Note 1 Using Swimming Pools in Hot Weather, Government of Western Australia, Perth. http://www.public.health.wa.gov.au/cproot/3802/2/Using%20Swimming%20Pools%20in%20Hot%20Weather.pdf	Health	#					
Department of Health (WA) 2010a. <i>Operational Directive Heatwave Policy</i> , Government of Western Australia, Perth. http://www.health.wa.gov.au/circularsnew/pdfs/12612.pdf	Health	#					
Department of Health (WA) 2010b. <i>Ross River virus and Barmah Forest virus in WA Environmental Health Guide – March 2010</i> , Government of Western Australia, Perth. http://www.public.health.wa.gov.au/cproot/1444/2/RRV%20and%20BFV%20in%20WA%202010.pdf	Health					#	
Department of Health (WA) 2008. <i>Health Impacts of Climate Change: Adaptation Strategies for Western Australia</i> . Government of Western Australia, Perth. http://www.public.health.wa.gov.au/cproot/1510/2/Health_Impacts_of_Climate_Change.pdf	Health	#	#	#	#	#	#
Department of Water 2004+. <i>Stormwater Management Manual for Western Australia 2004-2007</i> http://www.water.wa.gov.au/PublicationStore/first/44217.pdf	Eco					#	

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Rail Express 2010. <i>ARG Pushes for WA Grain Rail Upgrade</i> , 30 June. http://www.railexpress.com.au/archive/2010/june/june-30-2010/other-top-stories/arg-pushes-for-wa-grain-rail-upgrade	Inf	#					
Thomas, J. 2008. <i>Water Futures for Western Australia 2008-2030 - A water demand scenario modelling tool</i> . Prepared for Department of Water (2008) Government of Western Australia, Perth. http://www.water.wa.gov.au/Our+water+future/Predicting+the+future+demand+for+Water+in+WA/default.asp+x	Eco		#				
Western Australian Planning Commission 2011. <i>State Planning Strategy</i> . Government of Western Australia, Adelaide.	LUP, Inf		#				
Western Australian Planning Commission 2010. <i>State Planning Policy 3.1 Residential Design Codes</i> . Government of Western Australia, Perth.	LUP	#				#	
Western Australian Planning Commission 2006b. <i>State Planning Policy 3.4 Natural Hazards & Disasters</i> , Government of Western Australia, Perth.	LUP;		#	#	#	#	#
Western Australian Planning Commission 2006c. <i>State Planning Policy 2.9 Water Resources</i> . Government of Western Australia, Perth.	LUP, Eco		#				
Western Australian Planning Commission 2003. <i>State Planning Policy 2.6 State Coastal Planning Policy</i> . Government of Western Australia, Perth. http://www.planning.wa.gov.au/Plans+and+policies/Publications/139.aspx	LUP, Inf, Eco						#
ANALOGUE – GERALDTON-GREENOUGH							
ABC 2010a. Mid West firefighters take control, 2 March, http://www.abc.net.au/news/stories/2010/03/02/2834499.htm?site=wheatbelt	Eco			#			
ABC 2010b. Yandi Station bushfire contained, 3March, http://www.abc.net.au/news/stories/2010/03/03/2835661.htm?site=wheatbelt	Eco			#			
ABC 2010c. Fire closes Brand Highway, 8 March, http://www.abc.net.au/news/stories/2010/10/08/3033546.htm?site=wheatbelt	Eco			#			
ABC Lateline 2011. <i>Water Blue</i> , 8 May.	Inf		#				
AECOM Australia Pty Ltd 2010. <i>Climate Change Adaptation Action Plan</i> . Prepared for the Batavia Regional Organisation of Councils. http://www.cgg.wa.gov.au/sites/default/files/Climate_Change_Risk_Ass_Document_v2.pdf_-_Adobe_Acrobat_Pro.pdf	LUP, Inf, H/B, Eco,	#	#	#		#	#

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Bureau of Meteorology (n.d.) <i>Know your cyclone warning system</i> , Department of Science and Technology, Commonwealth of Australia	Health				#		
City of Geraldton-Greenough (n.d.) <i>2029 & Beyond Project</i> . http://www.2029andbeyond.com.au/	Eco					#	
City of Geraldton-Greenough 2010a. <i>City of Geraldton-Greenough Annual Report 2009-2010</i> http://www.cgg.wa.gov.au/sites/default/files/Annual%20Report%20-%202009-10%20-Adopted%20by%20Council%2023%20Nov%202010-web.pdf	Eco		#				
City of Geraldton-Greenough 2010b. <i>Geraldton-Greenough Water Planning and Management Strategy</i> .	Inf, Health		#				
City of Geraldton-Greenough (2010c) <i>Towards Sustainable Residential Development – Local Planning Policy</i> http://archive.cgg.wa.gov.au/sites/default/files/Towards%20Sustainable%20Residential%20Development_0.pdf	H/B		#				
City of Geraldton-Greenough 2010d. <i>Sporting Futures Report</i> .	Inf	#					
Department of Planning 2009. <i>Town Planning Scheme No. 3 (Geraldton) Government of Western Australia, Perth</i> . http://www.planning.wa.gov.au/The+planning+system/Region+schemes/Local+planning+schemes/487.aspx	LUP;					#	
Department of Planning and Ecoscape (Australia) Pty Ltd 2010. <i>Geraldton Regional Flora and Vegetation Survey March 2010</i> . Government of Western Australia, Perth. http://www.planning.wa.gov.au/Plans+and+policies/Publications/2141.aspx	Eco		#				
Department for Planning and Infrastructure 2008. <i>Mid-West Infrastructure Analysis</i> , Western Australian Planning Commission. Government of Western Australia, Perth.	Inf		#				
Department of Water 2010a. <i>Arrowsmith Groundwater Allocation Plan</i> , Report No. 28, Government of Western Australia, Perth. http://www.water.wa.gov.au/PublicationStore/first/95132.pdf	Eco		#				
ENV Australia Pty Ltd & Essential Environmental Services 2010. <i>Geraldton Greenough Water Planning and Management Strategy</i> . Prepared for the City of Geraldton Greenough. Government of Western Australia, Perth. http://www.cgg.wa.gov.au/files/cggwag/CI%20039%20ATTACHMENT%20CGG%20WPMS%20Final%20Jun2010.pdf	Eco		#				
Fire and Emergency Services Authority 2009. <i>Bushfire ADVICE for Moonyoonooka, east of Geraldton</i> , Government of Western Australia, Perth. http://internet.fesa.wa.gov.au/mediareleases/Pages/MediaRelease.aspx?ItemId=101	Eco			#			

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Northern Agricultural Catchment Council 2011. NACC Notes, Friday March 4, 2011, The Government of Western Australia, Perth. http://www.nacc.com.au/CMSModules/Newsletters/CMSPages/GetNewsletterIssue.aspx?issuelid=46#close	Eco		#				
Northern Agricultural Catchment Council, Department of Planning and Geraldton Port Authority 2010. <i>Coastal Processes Study – Greys Beach to Sunset Beach A Project of the Coastal Vulnerability and Risk Assessment Program</i> , September, Government of Western Australia, Perth. http://www.cgg.wa.gov.au/environment-waste/coastal-management/coastal-processes-study	Eco						#
Northern Agricultural Catchment Council 2010. <i>Geraldton Coastal Monitoring Program</i> , The Government of Western Australia, Perth. http://www.nacc.com.au/getdoc/2ebf3694-5fc2-4691-aa2a-31c44e10dbba/Geraldton-Coastal-Mon-Prog-.aspx	Eco						#
SES Unit, Fire and Emergency Services Authority of WA and Bureau of Meteorology (d.u.) <i>Stay Storm Safe</i>	Health				#		
Western Australian Country Health Service Midwest 2011. <i>Mosquito borne disease risk intensifies in Northern and Central WA</i> , media release dated 12 April, http://www.mmhr.org.au/pressreleases/story.asp?DocumentID=631	Health					#	
Western Australian Planning Commission 1999. <i>Geraldton Region Plan</i> . Government of Western Australia, Perth.	LUP, Health, Eco		#	#			
Western Australian Planning Commission 2010c. <i>The Greater Geraldton Structure Plan update 2010</i> . Government of Western Australia, Perth. http://www.planning.wa.gov.au/Plans+and+policies/Publications/2273.aspx	LUP		#				
Western Australian Planning Commission 2010. <i>Local Planning Scheme No. 5 (Greenough)</i> , Government of Western Australia, Perth.	LUP					#	
TARGET – BUNBURY							
ABC 2009. 'Tornado rips through Bunbury', Friday June 19 http://www.abc.net.au/news/stories/2009/06/19/2603581.htm	Inf, Eco				#	#	
Acacia Springs Environmental, Gravitas Consulting, Parsons Brinckerhoff and Landvision 2005. <i>Geopraphe Bay Coastal Catchment - Land Capability Assessment for Managing the Impact of Land Use Change on Water Resources</i> , Final Report for Department of Water. http://www.water.wa.gov.au/PublicationStore/first/82302_part1.pdf	Eco		#			#	

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
Bunbury Herald 2011. Looking Back: the Bunbury Tornado, 17 May. http://au.news.yahoo.com/thewest/a/-/full-coverage/9457921/looking-back-the-bunbury-tornado/#?=&cb=f2cc9b86682531&relation=parent.parent&transport=fragment&type=resize&height=20&ackData[id]=1&width=130	Inf				#		
City of Bunbury 2010a. <i>Annual Report 2009 - 2010</i> , http://www.bunbury.wa.gov.au/pdf/Residents/Publications/annual_reports/101222_Annual_Report_2009_2010.pdf	Inf, Health, Eco			#		#	
City of Bunbury 2010b. <i>Bunbury Aged Care Emergency Evacuation and Reception Plan</i> http://www.bunbury.wa.gov.au/pdf/Residents/Community_Law_&_Safety/Emergency_Management/Support_Plans/100603_Support_Plan_Aged_Evacuation_Procedures_2010.pdf							
City of Bunbury 2008. <i>Bunbury Bush Fire Response Plan</i> http://www.bunbury.wa.gov.au/pdf/Residents/Emergency_Management/BEMP/100603_Support_Plan_Bunbury_Bush_Fire_Response_Plan_2010.pdf	Health			#			
City of Bunbury 2007. <i>City Vision Strategy</i> http://www.bunbury.wa.gov.au/pdf/strategies/city_vision/071109_City%20Vision%20Strategy%20Sept%202007.pdf	LUP, Eco			#	#		
City of Bunbury 2004. <i>City of Bunbury Flood Management Strategy</i> .	Inf					#	
Department of Agriculture and Food 2006. <i>Climate Change, Vulnerability and Adaptation for South West Western Australia 1970 to 2006</i> , Government of Western Australia, Perth.	Eco		#				
Department of Environment and Conservation 2009. 'Butler's corella', <i>Fauna Note 19</i> , Government of Western Australia, Perth.	Eco		#				
Department of Planning (n.d.) 'Coastal Vulnerability Assessment Projects', Government of Western Australia, Perth. http://www.planning.wa.gov.au/Plans+and+policies/Statewide+planning/Coastal+vulnerability/default.aspx	Eco					#	#
Department of Water 2010b. <i>Water for the Future: South West Groundwater Areas Management Plan</i> , Government of Western Australia, Perth.	Inf		#				
GHD 2009. <i>Report for Collie Urea Project – Public Environmental Review</i> . Prepared for Perdaman Chemicals and Fertilisers, Perth. http://www.perdaman.com.au/media/7487/sections%201%20and%202%20-%20introduction%20and%20project%20location.pdf	Inf		#				

Document Reference	Aspects	Climatic factor					
		Heat	Drought	Bushfire	High wind	Intense Rainfall/ Flooding	Coastal
South West Catchments Council 2011a. <i>Wind erosion projects a 'blow away' success</i> , Media Release 16 March 2011 http://www.swcatchmentscouncil.com/uploads/Media/Wind%20erosion%20projects%20a%20blow%20away%20success_MR.pdf	Eco				#		
South West Catchments Council 2011b. <i>Innovation in the Wattle Creek Catchment</i> , SWCC E-Newsletter, 27 May 2011, Article http://www.swcatchmentscouncil.com/index.php?mact=News.cntnt01_detail.0&cntnt01articleid=109&cntnt01origid=100&cntnt01detailtemplate=enews_template&cntnt01returnid=104	Eco				#		
South West Development Commission 2010. <i>Strategic Plan 2010-2025</i> , Government of Western Australia, Perth.	Inf		#				
Water and Rivers Commission 1997. A systematic overview of environmental values of the wetlands, rivers and estuaries of the Busselton-Walpole region. <i>Water resource allocation and planning series</i> . Report WRAP 7	Eco					#	
Western Australian Planning Commission 2011. <i>City of Bunbury Town Planning Scheme No 7</i> . Government of Western, Australia, Perth. http://www.planning.wa.gov.au/The+planning+system/Region+schemes/Local+planning+schemes/439.aspx	LUP	#					

5 DISCUSSION

The hypothesis that more southerly target communities might learn from their northerly analogues as a result of the latter being more advanced in their response to often more extreme climatic factors has been tested in this study. The conclusions which can be drawn from the analysis of policy set out above are mixed. There is no discernibly clear pattern which suggests that this hypothesis can be upheld in most instances. But there are examples in all the states studied that point to differences in policy which might be interpreted as more advanced policies and practices in analogue communities in certain instances.

5.2 LAND USE PLANNING

Generally in land use planning policy, there was little evidence to suggest that analogues were responding to climatic drivers in significantly different ways to targets. The main reason seems to be that in all three states studied, the policy framework is top down and therefore local policy is, of necessity, a reflection of state wide directions. The common incidence in all three states of mechanisms aimed at standardisation of structure, policy wording and range of policy coverage in local plans also masks clear distinctions in land use planning policy between analogues and targets. There is ample evidence that some aspects of planning policy at the local level are a response to climatic factors. Shade planting to counter heat, restrictions of development in flood plains and bushfire prone areas and specification of setbacks for coastal development are all common responses. Planning policy at a strategic level tends to focus on natural hazards, such as floods, which result from climatic factors, and also on climate change, suggesting that local planning should develop appropriate policy.

5.3 INFRASTRUCTURE

Regarding infrastructure, the clearest differences between analogues and targets were in respect to water supply issues. In Queensland, whilst both areas under consideration were cognisant of the restrictions that water availability placed on development, the analogue community, in response to a pressing need to supply expanding industrial developments, was prepared to invest \$20 in a water transfer pipeline to ensure supply even though fluctuating conditions meant that this would only be needed during extreme drought periods. The response to coastal erosion was also a policy area where differences were apparent, particularly in Queensland. A policy of managed retreat was favoured in the analogue situation, whilst harder defences were used in the target to try to defend coastal development. Whilst both communities are displaying a policy response to a similar climatic driven problem, there is insufficient evidence to determine the reason for the difference. It may be that monitoring the two solutions could provide evidence to support one approach over the other.

Concern about restricted water supply in all of the analogue communities appears to put them somewhat in advance of the targets, if only in terms of policy implementation. In Queensland, although both analogue and target regions were developing water grids, the more northerly analogue seems to be in advance, largely because of the pressing nature of the problem. In WA the analogue also appears to be ahead of the target in its drought response, again because of the more pressing urgency for a policy response to extreme conditions. This response involves increased water reuse and recharge of aquifers. Water shortage is in fact the climatic factor which, across most of the aspects studied, has provoked a response that could be noted as different between analogues and targets. See Box 7 for further discussion about what we have learned regarding water infrastructure. In most instances, however, the targets have also suffered supply restrictions and are making policy provisions to address this problem, but the urgency of the problem is not as pressing. Extreme heat is an area where a different response may be discernible between analogues and targets. In some instances this difference was more obvious from interviews than from policy documents, suggesting that awareness of the issue was relatively recent. Worker safety during heat events was a frequently noted issue in several states.

Provision of shade in public places was a common planning policy and organising indoor sporting events was notable as response in the WA analogue.

Box 6 Water Infrastructure

Box 7. Water Infrastructure

The northern analogues in all 3 states are dealing with the challenge of industry and natural resources driven growth, but in a dry climate. All face the challenge of water shortages. Town of Northampton actually ran out of water, with water needing to be carted to provide the supply. A water supply pipe has since been installed.

In some cases, the competition for scarce water leads to conflict; for example, the \$2 billion Karara Magnetite Project in WA's Mid West (near Geraldton) has applied for a 5 gigalitre water licence, about 80% of the available recharge in the subsection of the Parmelia Aquifer, which has created a clash between mining and farming interests. A local farmer asked: 'How do you calculate workout recharge in a dry environment where we are getting less rainfall. It's a known fact. The last 10 years at Mingenew the rainfall has dropped off considerably...like the rest of Western Australia' (ABC Lateline, 8 May 2011). Similarly, the Oakajee port and infrastructure project of around \$6.7 billion would need to import water from a major groundwater resource.

In WA's South West, water issues have loomed large for the \$3.5 billion Collie Urea Plant, which turns coal into urea (fertiliser). Groundwater in the Upper Collie basin is fully allocated due to high demand from the coal-based industries. Perdaman has gained agreement in principle from the Department of Water for a water allocation from Wellington Dam, provided it develops other water supply options (GHD, 2009). Recognising that serious water shortages could hamper the surge of growth and progress in Central Queensland, the Gladstone Area Water Board (GAWB) undertakes a new regional approach to water supply planning and has developed the Central Queensland Regional Water Supply Strategy (GAWB, December 2006). The mechanisms proposed to meet the challenges include new pipelines to link key water infrastructure within and outside the region to areas of greatest need. In this way, a regional water grid will be established, forming a first step towards a state wide water grid.

Whilst Seqwater is also establishing a South East Queensland water grid, there are lessons to be learned from the more advanced stage of the GAWB and its Central Queensland water grid. Similarly, Seqwater's recognition that catchments are complex systems could have lessons for GAWB.



Images: Laying Karara water pipeline (above) and Karara township (top)

5.4 HOUSING AND BUILDING

Regarding housing and building, it is clear that differing climates do produce different outcomes in respect to policy and building specifications. These differences are apparent in the deemed-to-satisfy provisions of the BCA for energy efficiency (SA), structural standards for high velocity winds (Queensland and WA) and intense rainfall (WA) between the analogue and target communities. In addition, alternative design solutions for energy efficiency using NatHERS software allow for the use of localised weather data (for all pairings), and local planning policy for water efficiency measures is more stringent for the WA analogue. Although energy efficiency requirements and their variations for different climate zones are well established, it is worth noting that the intention of these measures is to reduce greenhouse gas emissions. Creating acceptable internal conditions in buildings during extreme or prolonged heat waves is a separate and related issue.

5.5 HEALTH SERVICES

In respect to health services, state wide provisions often tend to mask local differences. However, a lack of research on the actual impact of heat or drought on regional communities suggests this is a fertile area for future research. Where these factors are recognised as important issues, as in the agricultural Mid West of WA and in regional SA, then the analogue

can be seen to have developed innovative mental health programs to address issues in the agricultural community. This appears to be a very clear example of potential analogue/target learning. A general point that emerged from a number of interviews and workshops concerned the relationship between temperature and vulnerability. It was suggested that relative change in temperature is the crucial factor when considering population vulnerability to heat. In locations where it is frequently very hot i.e. Port Pirie and Gladstone, several interviewees commented that the local population are used to it and behave accordingly. However, we found little evidence of significantly different behaviour. Thus, it could be argued that people do adapt physiologically and psychologically. However, when significant fluctuations in temperature occurred, problems were noted. These included workers suffering heat exhaustion. So climates which have more or less stable temperatures are possibly better equipped to handle heat than those like South Australia where temperatures can fluctuate by as much as 20 degrees from one day to the next. This could be a fertile field for further research. The problem in defining heat and heat wave across jurisdictions was most evident in Queensland where the influence of humidity on extreme heat was noted. Establishing appropriate policy to reflect the large variation in climate, which exists across Australia, remains a challenge and forces localised interpretation and implementation.

5.6 ECOSYSTEM SERVICES

In the analysis of ecosystem services, both Queensland and Western Australia displayed a similar analogue/target difference in respect to floodplain management. In Queensland the concentration on floodplain protection in the analogue appears to manage extreme rainfall and tidal surge better than in the target. The protection of floodplains displayed the added benefit of protecting the coastal environment from sediment outflow during extreme events. A parallel situation was evident in Western Australia where the analogue community relies on regional flooding to replenish floodplains for horticultural use and animal grazing. The target community, in contrast, has installed drains which take superficial groundwater and stormwater from the area as quickly as possible to minimise the extent of areas affected by flooding. As a result, the terrestrial based and riverine/wetland ecosystems in the target community are less able to deliver treatment of floodwaters and may impact the coastal ecosystems to a greater extent than previously.

5.7 RISK MANAGEMENT

Many of the communities studied were undergoing rapid growth, especially the regional analogues adjacent to the resource rich regions of Western Australia, Queensland and South Australia. At the same time, it was found that growth was constrained by climate factors, especially shortage of water. Storms, more intense rainfall and flooding caused devastation in some areas, disrupting regional infrastructure and putting lives at risk. The regional settlements and heavily populated urban areas, all located along the coast, were also facing sea level rise and the risk of storm surges and flooding, to varying degrees.

Interviews with the various councils, coupled with the analysis of policies and plans, assisted in highlighting their key issues of climate related concern. For example, the City of Geraldton-Greenough (Interview, 17 February 2011) noted that the main issues of concern were sea level rise, increased temperature, and reduced rainfall. The City of Whyalla (Interview, 29 November 2011) highlighted the die back of vegetation resulting from heat and drought, storms, flooding and tidal inundation as the main threats. The Moreton Bay Regional Council is concerned about the impact of heat and 'unplanned for weather events' such as storms and flooding on its living conditions, especially for the ageing population and lower socio-economic groups. This may impact on its whole desirability as a place to live and economic base, with the risk that some sections of the community may migrate southward to more favourable climate zones (Interview, Moreton Bay Regional Council, 25 January 2011; Climate Risk Pty Ltd, 2009). Thus, such climate risks may impact upon economic development objectives and planning, with the need for such risks to be seen in the light of demographic profiles (as outlined in this report) and to be integrated with key strategic plans.

The current analysis has sought to take a subjective approach to identifying risk as explained above. Using commonly accepted risk assessment methodology (Standards Australia, 2009), it should be possible to determine the severity or level of such risks based upon their perceived likelihood and consequences, and this analysis could, in turn, assist in determining priorities for managing or reducing risks. The matrices set out above form a starting point in this analysis, but more detailed quantified information would need to be collected to progress this analysis. This could form a useful line of investigation for Part Two of the Learning from Regional Analogues project. Nevertheless, it should be recognised that risk is location specific and risks may be of variable significance to different actors and agencies, for example, state or local government, residents, businesses or utility companies. In light of the present discussion, drought emerged as the highest risk affecting economic development within northern analogues, and water infrastructure (such as water grids) thus emerged as a key requirement and priority. It should be noted that risk management methodology also has the potential to highlight positive opportunities arising from climate factors, especially where innovative integrated approaches are taken. For example, as noted within this report, a wind powered desalination plant was mooted for Port Pirie, utilising increased winds to address the challenge of water shortages (Hughes PR, 2010).

Risk management is an established mechanism familiar to many communities, including regional and local government. Many of the stakeholders interviewed as part of this study highlighted risks, associated liabilities, possible economic losses and increased social and health impacts. Some local government jurisdictions have been successful in implementing risk management studies related to climate factors. For example, the Local Government Association of SA (2010) has used the Mutual Liability Scheme as a mechanism for SA local governments to undertake climate risk studies, with over half of its members undertaking such studies (Interview, Local Government Association South Australia, 29 September 2010). However, gaining subsequent funding to address these issues is often problematic, as was evidenced in interviews with the City of Bunbury (21 February 2011) and Port Pirie Regional Council (7 December 2010). The City of Geraldton-Greenough, though, was actively seeking to highlight the risk of climate factors upon the city's finances, and thereby gain the attention of councillors and relevant authorities (Interview 17 February 2011). In an endeavour to leverage greater resources and political power, councils within some regions were forming clusters or groups, and tackling climate risks on a regional basis. For example, with other councils in the region, the City of Bunbury has formed 'The Peron Naturaliste Partnership' to address coastal adaptation in a cooperative manner (Interview, City of Bunbury, 21 February 2011). The WA Department of Health has been a national leader in applying risk management in determining health and social adaptation strategies for Western Australia (Department of Health (WA), 2008). This could well form a model for application within other jurisdictions, within other sectors and across sectors.

5.8 GENERAL DISCUSSION

One of the fundamental challenges associated with this work is how to attribute differences in management practice observed within two communities to local climatic conditions, when those communities are located in relatively close proximity to one another and therefore have relatively similar climates. For example, only the analogue/target pairings in South Australia are situated in different Building Code of Australia climate zones, and overall, the pairings lie within just a few hundred kilometres of one another. It is contended that the choice of pairings needed to reflect realistic future climate scenarios. If they were significantly different, then the target would be unlikely ever to experience the climate of the analogue and as result any potential learning would be viewed as circumspect. But the target analogue choices make it extremely difficult to attribute differences to climate. It is difficult to identify large differences in policies and measures between communities where the climate and governance contexts are not radically different. This is a fundamental problem with the research concept which raises questions over the potential benefits of embarking upon Part Two of the research.

A point raised in a number of the interviews concerned the apparent disconnection between policy and practice. This manifests itself in a number of ways. First, local council officers often expressed frustration at state driven policy that does not seem to take local circumstances into

account. The standardisation of policy modules and wording in South Australia provoked criticism that local policy makers sometimes felt unable to push forward with policy initiatives because they did not conform to state wide directives and frameworks. Secondly, they suggested that sometimes policy was, in practice, unenforceable because of lack of detailed supporting data and evidence. An example is the restriction on development in flood prone areas. Lack of data and detailed maps backed up by high quality research means that developers may successfully appeal planning decisions in such areas. Thirdly, a lack of policy integration between different areas of council activity was frequently mentioned as a problem. Planning policy which does not take ecosystem services into account; ecological policy which contradicts emergency service advice on bushfire risk and planning policy on density, which may exacerbate heat island effects, are all examples. In respect to land use planning, this issue varies between states and partly reflects the differing interpretation of the appropriate boundaries of land use planning in the different locations. Queensland and Western Australia generally appear to have policy which is better integrated with these other diverse policy areas, whilst South Australia operates a more restricted statutory land use planning system. A second aspect, already alluded to in section 1.3, relates to the strength of policy. Recognition of an issue, the existence of policy to address the issue and evidence of implementation of the policy appear to be three useful distinctions which could form a basis for further analysis, should Part Two of the *Learning from Regional Analogues* research project be progressed. The present report has sought to identify these distinctions where possible, but not to draw any conclusions from them. A complicating factor is the dynamic nature of policy which means that at any one time there is likely to be both longstanding policy and new policy under review. When multiple layers of governance are also taken into account, it can be difficult to reach a judgement on the relative strength of policy when contrasted between two separate locations. This aspect constitutes a weakness of the *Learning from Regional Analogues* concept, which it is difficult to address in a satisfactory manner.

Concern about public response to policy and data on climatic issues was also a problem, especially in the context of a changing climate. Governments tend to want populations to take responsibility for their own safety so that publicly funded services can concentrate on major emergencies. But the popular view that everyone expects to be rescued in an emergency was held to be very prevalent despite the fact that this is unlikely to be possible in practice. At the same time, there is public resistance to data being made freely available on, for example, bush fire or flood risk because of concern about the impact on property values.

Governance issues are central to this study. A key issue which emerges from the analysis is the centralising and standardising role of state governments, which set the agenda and dictate much of the content of local policy, especially in respect to land use planning. As a result, it is difficult to identify evidence of policy differences between analogues and targets. Governance is fundamental to how organisations manage climate risk. There is evidence of collaborative regional approaches to decision-making, which in some cases may be viewed as tempering the pervasive influence of state government. Examples of effective regional collaborations were the Batavia Regional Organisation of Councils, as seen with the BROCCAP (AECOM Australia Pty. Ltd., 2010) and the Eyre Peninsula Natural Resources Management Board (such as the Eyre Peninsula Regional Sector Agreement Pursuant to the Climate Change and Greenhouse Emissions Reduction Act, 2007). Valuable information and perspectives were gained from discussion with regional development commissions in WA and with NRM Boards in SA. The regional delivery of programs was also apparent in Queensland with state government agencies referring to regional approaches in each of the analogue and target communities, and local governments preferring regional approaches to leverage funding. Hence, there are expected benefits to be had from local communities communicating and networking across boundaries. Further work with local government should consider a framework where networks are developed to respond to the southward movement of climatic factors.

5.7 CONCLUSIONS

The question of whether target communities might usefully learn from analogue communities is addressed by the methodological approach developed in this report. The research has collected

extensive policy evidence across the three target and analogue pairs and done an initial analysis to determine whether a more detailed comparison, which might yield valuable policy lessons in respect to the way analogues are dealing with climate and how targets might in future deal with a similar climate, is feasible.

Overall, we contend that the approach developed above has proved effective in clarifying the utility of the *Learning from Regional Analogues* concept. It demonstrates that in many respects there is no clearly distinguishable difference between analogue and target communities in respect to their policy stances. State driven, top down policy effectively demands similar approaches in both communities. This is particularly the case with most land use planning policy and some health policy. There are some examples of differences in policy between analogue and target communities, but these are sporadic rather than systematic, and it is not possible on the strength of this analysis to determine whether these are climatically driven or not. Building and housing may be an exception to this general finding. The requirements of the BCA demand different responses, which are climate driven, in different locations, and even the existence of a national code of practice allows for such detailed localised differences in approach.

Heat and drought seem to elicit a fairly consistent response between analogues and targets. Bushfire, wind and coastal storm surge tended to be considered more or less effectively in all locations though occasionally employing different solutions. Flooding risk was noted in most areas and provoked policy responses. But it was notable that some locations (in some cases target communities) were in advance of others in respect to the research that had been carried out to support and validate policy, thus assisting with its implementation. Flood mapping is a vital accompaniment to a valid flood control policy and its availability was variable.

Different approaches to similar problems, notably flooding and coastal defence were notable between some pairings. These policy differences may not be a direct response to climatic differences. They may represent different perceptions of financial risk or differing settlement patterns. Nevertheless, they offer scope for learning from the relative success of differing solutions. Monitoring of the relative success of differing flood and coastal defence policies probably remains a work in progress for many councils and state agencies and its analysis offers a potentially valuable area for further research. The interface between land use planning and flood management using pipes and drains, or relying on natural ecosystem services, was a difference that was apparent between some analogue/target pairings and could provide a fertile field for further analysis.

In respect to dealing with drought, which appears as the most pressing concern in a number of locations across Australia, there is evidence of analogue responses which are innovative in health and infrastructure services. Innovative regional responses were apparent in South Australia and Western Australia in particular, in respect to health issues resulting from the impacts of drought on agricultural communities. However, these are relatively isolated examples and are not sufficiently common to imply that the approach tested in this study is sufficiently robust to become established as a model for future adaptation policy formulation.

A number of potential case studies, which might merit further investigation, are identified in the Boxes embedded in the text above. These may be used as a quick reference guide to analogue/target differences, albeit in a limited range of circumstances, which have been identified by the research. But overall this attempt to test the *Learning from Regional Analogues* concept has demonstrated that the concept is unlikely to yield broad evidence of significant differences in policy between analogues and targets. This conclusion rests on a number of observations. First, the climate characteristics of the paired communities are different but not remarkably so. Average temperatures that differ by 3 to 4 degrees and rainfall which differs by a factor of 10% may not be sufficient to provoke significantly different policy responses in the paired locations. In most instances, the target communities are seeking to address similar concerns about heat and drought as the analogues. Similarly, weather extremes causing floods and bushfires, have been experienced in the target communities in the past and a policy awareness of risk is evident. It could be argued that government institutions only intervene to

implement a particular policy or measure to adapt to climate when there is a perceived policy or market failure. The research has identified several examples of policy in the analogue communities that relates to climate, and is intended to redress market failures (e.g. agricultural productivity issues in Geraldton and industrial water supply problems in Gladstone) but the target communities are also aware of similar issues. There may be benefit in sharing experiences of how policy is generated and applied. All the workshops in the three states confirmed a general desire on the part of participants to know more about practices elsewhere, though this may be as much driven by a desire to confirm existing policy approaches as to discover innovative examples. Topographic, socio-economic and political differences between targets and analogues may be just as important as climatic differences in driving policy effort in particular directions. More detailed research under the potential Part Two of this project may be able to identify more clearly how these distinctions play out. However, if such research is undertaken, it may be better to frame it as a more general examination of the range and nature of adaptation policy viewed in the context of climate change, than as an attempt, as here, to identify climatically driven policy in analogue and target communities. The most problematic aspect of trying to identify analogue/target policy differences stems from the overarching presence of state policy which drives local policy response across most issues. This observation, of course, affirms current governance arrangements, but it obscures most potential for innovation at the local level and renders the current approach questionable in terms of the validity and value of its findings.

6 PROJECT REFLECTIONS AND RECOMMENDATIONS

The Learning from Regional Analogues project has proved to be an interesting and, at times, challenging journey for the research team. In its original conception, sitting within the Synthesis and Integrative theme and covering aspects from hard infrastructure and building regulation, through land use planning to health care and emergency management as well as ecosystem services, the scope was necessarily broad. This breadth was reflected in an extensive array of legislation and policy vehicles in each of the three quite different Australian states studied. At the outset, the challenge was substantial and interdisciplinary in its nature. Early in the process, the team noted that gaining cooperation from the analogue and partner communities would be vital to success. Initial soundings of the initial choices of analogue/target pairings proved that the potential stakeholder appetite for involvement in the study was variable. Several of the identified local councils demonstrated great enthusiasm and willingness to be involved. Others were less willing. It took some time to achieve agreement from all the final analogue partner pairs and the working relationships which have emerged over the period of the research have been variable. Generally, the research team received a good level of cooperation from state government and other agencies and we are extremely grateful to the wide range of organisations and individuals who have provided generously of their time and resources. Whilst data collection from policy documents proved a relatively straightforward process, interviews and workshops were more challenging. There are a number of reasons for this. The definition of the nature and aims of the project as a whole remained an issue for some time. In particular, the distinction between policy (which by necessity is forward looking) on climate change and policy which has developed as a result of climatic influences, proved problematic. We are extremely grateful to the NCCARF team for their patience and determination to ensure that we reached a positive outcome. The workshoping process also proved a dynamic environment in which the team progressively learned how best to achieve cooperation and feedback from stakeholders. We commenced with a strong emphasis on presentation of findings by the research team. Indeed, we felt that stakeholders would be more likely to be involved if they felt they were being presented with potentially useful results from the study. Increasingly, we moved to a more interactive workshop format but even then the limitations of time and resources suggest that a complete understanding of policy priorities, risk assessment and policy robustness, assessed in respect to its longevity, degree of implementation and success, are tasks for a future analysis.

Data proved difficult to access in several instances. Whilst we have included a short profile of each community in the report, it would have been valuable to include data on water and energy consumption, especially at the household level, to allow for comparisons to be made between analogues and targets and between states. This data is mostly held by commercial utility companies and has proved to be inaccessible. A further work program in this field could benefit from access to such data. This approach might demonstrate whether communities are adapting to climatic conditions such as drought and heat and whether that adaptation is sustainable or represents maladaptation. Health data also proved problematic as a result of problems of confidentiality and the potential for cases to be identifiable in situations where small spatial areas were considered.

The evidence on climatic considerations in policy across a variety of aspects set out in this report suggests that there is scope for further research.

6.2 RECOMMENDATIONS FOR FURTHER RESEARCH

On the basis of the findings of the Learning from Regional Analogues project reported above, the following are suggested as potentially valuable opportunities for further research:

- Monitoring and analysis of identified analogue/target policy differences in respect to:

1. Flood control
2. Building and housing regulation and construction
3. Water supply infrastructure
4. Drought response policy

A few of the above relate to specific aspects as defined in the report. Others, such as drought response, cross boundaries between planning, housing and building, infrastructure, health and ecosystem services.

- Extend the approach taken in this report to develop criteria to allow self assessment of climate related policy development by stakeholders. A tool to assist policy agencies to benchmark themselves against other agencies could prove a useful device to accelerate policy response to climate change. This could be integrated into local council risk assessment approaches.
- Test the application of assessment techniques such as sustainability appraisal in the formulation of policy coherence to maximise the effectiveness of climate related policy within and between organisations.
- Address climate adaptation across government agencies in one state, for example, using housing, agriculture, water, health, sport and recreation using appropriate policy analysis techniques.
- Analysis of energy and water use in analogue/target locations to determine whether housing and building, infrastructure and ecosystem management are optimal responses to local climate.
- Analyse building occupant behaviour and response, the adaptation of new and existing building designs, derivation of new meteorological data and analysis of energy consumption patterns for differing climate conditions.
- Review the innovatory policy formulation and delivery mechanisms attempted, for example, in Geraldton, WA to assess whether there is scope for climate related policy to filter up, as well as down, within states.

This report should be distributed to participating organisations with a request for feedback on the potential value of pursuing this line of investigation or any of the recommendations set out above.

Finally, we strongly recommend NCCARF considers setting up a program to share policy and innovation between councils across Australia to inform and accelerate policy development in respect to climate.

ACRONYMS AND ABBREVIATIONS

ARG	The Australian Railroad Group
BCA	Building Code of Australia
BoM	Bureau of Meteorology
BROC	Batavia Regional Organisation of Councils
CGG	City of Greenough-Geraldton
CPRS	Carbon Pollution Reduction Scheme
CWMS	Community Wastewater Management Scheme
CSIRO	Commonwealth Scientific and Research Organisation
DWLBC	Department of Water, Land and Biodiversity Conservation, South Australia.
DEH	Department of Environment and Heritage
DENR	Department of Environment and Natural Resources, South Australia.
Eco	Ecosystem Services
GCM	Global Climate model
GRC	Gladstone Regional Council
Inf	Infrastructure
IPCC	Intergovernmental Panel on Climate Change
LDP	Local Development Plan
LGA	Local Government Association
LUP	Land Use Planning
MBRC	Moreton Bay Regional Council
MWDC	Mid-West Development Commission, Western Australia
NACC	Northern Agricultural Catchment Council, Western Australia
NCCARF	National Climate Change Adaptation Research Facility
PAE	City of Port Adelaide Enfield
PPRC	Port Pirie Regional Council
SWDC	South-West Development Commission, Western Australia
TMY	Typical Meteorological Year
WUE	Water Use Efficiency
SES	State Emergency Service

GLOSSARY

Adaptations are actions taken to help communities and ecosystems moderate, cope with or take advantage of actual or expected changes in climate conditions.

Climate summarises the average, range and variability of weather elements, e.g. precipitation, wind speed, air temperature, humidity, and sunshine hours (solar radiation), observed over many years (typically > 30 years) at a location or across an area .

Climate variability refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events. Examples of climate variability include extended droughts, floods, and conditions that result from periodic El Niño and La Niña events.

Climate change refers to shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer). Contemporary climate change refers to anthropogenically driven changes in the climate as a result of changes to the composition of the atmosphere via the addition of greenhouse gases.

Drought, in general, means acute water shortage. When dry conditions are not relieved by equally wet periods over a number of years, or when a shorter period of dry is exceptional, it is commonly called drought.

Littoral zone (in coastal environments) extends from the high water mark, which is rarely inundated, to shoreline areas that are permanently submerged. It always includes the intertidal zone and is often used to mean the same as the intertidal zone. However, the meaning of 'littoral zone' can extend well beyond the intertidal zone.

Risk is the product of consequences and likelihood – what can happen, and what are the odds of it happening. Both of these factors are important in determining whether, and how, we address specific risks.

R value is the Thermal resistance value

U value is the Thermal transmittance value

Vulnerability to the impacts of climate change is a function of exposure to climate conditions, sensitivity to those conditions and the capacity to adapt to the changes. Vulnerability is typically described as being a function of three overlapping elements – exposure, sensitivity, and adaptive capacity. For example, agricultural vulnerability to climate change is described in terms of not only exposure to elevated temperatures, but also crop yield sensitivity to the elevated temperatures and the ability of farmers to adapt to the effects of that sensitivity, i.e. by planting more heat-resistant cultivars or by ceasing to plant their current crop altogether. Vulnerability is place based – region rather than country, and needs to match the scale of decision-making of the collaborating stakeholders .

Weather describes atmospheric conditions at a particular place in terms of air temperature, precipitation, wind speed, pressure and humidity.

BIBLIOGRAPHY

- Adelaide and Mt Lofty Ranges Natural Resource Management Board 2006. Annual Report: 1 July 2005 – 30 June 2006.
http://www.environment.sa.gov.au/dwlbc/assets/files/AMLRNRM_AnnualReport_20506.pdf
- ABCB 2010
- ABCB 2011 *National Construction Code of Australia*. Volumes 1 and 2. Building Code of Australia. Australian Building Codes Board. May.
- Agriculture and Related Resources Act 1976*, (Government of Western Australia).
- Australia and NZ Standard AS/NZS 1170-2011: Structural Design Actions – Wind Actions
- Australian Standard AS 3745-2010 Planning for Emergencies in Facilities
<http://infostore.saiqlobal.com/store2/Details.aspx?ProductID=1439257>
- Bengtsson J., Clément V. and Davies T. 2008 *Adaptation to Climate Change through Building Regulation*. June. Edge Environment Report.
<http://www.edgeenvironment.com.au/docs/ANU%20climate%20change%20adaptation%20-%20Edge%20Environment%2021Nov08.pdf>
- Biosecurity and Agricultural Management Act 2007*, (Government of Western Australia)
- BRANZ 2007. *An assessment of the need to adapt buildings for the unavoidable consequences of climate change*. Report to Australian Greenhouse Office. Department of Environment and Water Resources by BRANZ Limited. ISBN: 978-1-921297-64-9.
- Bureau of Meteorology 2011a. *Tropical Cyclone Warning Services*,
<http://www.bom.gov.au/cyclone/about/warnings/>
- Bureau of Meteorology 2011b. *Tropical Cyclone Information for the Australian Region*
<http://www.bom.gov.au/cgi-bin/silo/cyclones.cgi?region=aus&year=2006&eyear=2006&loc=0>
- Bureau of Meteorology 2011c. *Previous Tropical Cyclones*,
<http://www.bom.gov.au/cyclone/history/index.shtml#history>
- Bureau of Meteorology 2010. *Climate statistics for Australian locations*. Australian Government.
<http://www.bom.gov.au/climate/averages/index.shtml>
- Bushfires Act 1954*, (Government of Western Australia).
- Centre for Research Cooperation (CRC) for Rail Innovation 2011. Track Stability Management to Improve Safety and Track Capacity
<http://railknowledgebank.com/Presto/content/Detail.aspx?ctID=NzImMTEzYigtNjgwYS00Yjc2LWJkN2YtN2IyYWZhMDY2NTYy&rID=Njc=&sID=Mg==&bckToL=VHJ1ZQ==&qcf=&ph=VHJ1ZQ==>
- City of Bunbury (n.d.) *Local Economy*, <http://www.bunbury.wa.gov.au/index.php?pageId=22>
- City of Geraldton-Greenough (n.d.a) *Where is Geraldton-Greenough?*
<http://www.cgg.wa.gov.au/city-surrounds/facts-figures>

City of Geraldton-Greenough (n.d.b) *City Surrounds*. <http://www.cgg.wa.gov.au/city-surrounds> .

City of Geraldton-Greenough (n.d.c) *Economic Overview*. <http://www.cgg.wa.gov.au/business-industry/economic-overview/>

City of Geraldton-Greenough (n.d.d) *2029 and Beyond*. <http://www.cgg.wa.gov.au/about-council/2029-and-beyond>

City of Playford (n.d.a.), *Welcome*. <http://www.playford.sa.gov.au/site/page.cfm>

City of Playford (n.d.b.), *Snapshot of the City of Playford*. <http://www.playford.sa.gov.au/site/page.cfm?u=382>

City of Port Adelaide Enfield 2011. *Water Resources*. <http://www.portenf.sa.gov.au/site/page.cfm?u=296>

City of Port Adelaide Enfield 2008. *Submission to 'Inquiry into climate change and environmental impacts on coastal communities'*
<http://www.aph.gov.au/house/committee/ccwea/coastalzone/subs/sub059.pdf>

City of Port Adelaide Enfield (n.d.a), *Council Area Map*. <http://www.portenf.sa.gov.au/site/page.cfm?u=997>

City of Port Adelaide Enfield (n.d.b), *Profile of Port Adelaide Enfield*
http://www.portenf.sa.gov.au/webdata/resources/files/City_of_Port_Adelaide_Enfield.pdf

City of Whyalla (n.d), *Location*, <http://www.whyalla.com/site/page.cfm?u=156>

Climate Change and Greenhouse Emissions Reduction Act 2007, (Government of South Australia).

Climate Risk Pty Limited 2009. *Scoping Climate Change Risks for MBRC*. Prepared for Moreton Bay Regional Council. August 2009
<http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/environment/Scoping-Climate-Change-Risk.pdf>

Coast Protection Board, South Australia 1992. *Coastal Erosion, flooding and sea level rise standards and protection policy*, Coastline:26, Government of South Australia, Adelaide.

Commonwealth of Australia 2011. *National Water Security Plan for Cities and Towns*, <http://www.environment.gov.au/water/policy-programs/cities-towns/index.html>

Conservation and Land Management Act 1984, (Government of Western Australia).

CSIRO and BoM 2007. *Climate change in Australia* CSIRO and Bureau of Meteorology, http://www.climatechangeinaustralia.gov.au/technical_report.php

Department for Transport, Energy and Infrastructure 2005a. *Strategic Infrastructure Plan for South Australia* Government of South Australia, Adelaide

Department for Transport, Energy and Infrastructure 2005b. *Regional Overview*, Government of South Australia, Adelaide

Department of Climate Change 2009. *Climate Change Risks to Australia's Coasts: A first pass national assessment*, Commonwealth of Australia.
<http://www.climatechange.gov.au/publications/coastline/climate-change-risks-to-australias-coasts.aspx>

- Department of Employment, Economic Development and Innovation 2010. *South East Queensland Water Grid*. The State of Queensland, Brisbane.
<http://www.dip.qld.gov.au/segwatergrid>
- Department of Environment and Conservation, Western Australia 2010. Climate Change Science 'Our Climate is changing' <http://www.dec.wa.gov.au/content/view/full/5172/2189/1/1/>
- Department of Environment and Resource Management 2009. *ClimateQ: toward a greener Queensland*, Queensland Government, Brisbane.
<http://www.climatechange.qld.gov.au/pdf/climateqreport/climateqreport.pdf>
- Department of Health (SA) (2010a. *Draft Mid North 10 Year Local Health Service Plan 2010-2019*, Mid North Health Advisory Councils, Mid North Health Service, Country Health SA Hospital Inc., Government of South Australia, Adelaide
<http://www.countryhealthsa.sa.gov.au/LinkClick.aspx?fileticket=bbSTAaKT4Ko%3d&tabid=596>
- Department of Health (SA) 2010b. *Whyalla Hospital and Health Services*, Government of South Australia, Adelaide.
<http://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/health+services/hospitals+and+health+services/country/eyre+peninsula+and+western/whyalla+hospital+and+health+service>
- Department of Health (SA) 2008. *GP Plus Health Improvement Plan*, Government of South Australia, Adelaide.
- Department of Health (WA) 2008 Health Impacts of Climate Change: Adaptation Strategies for Western Australia. Government of Western Australia, Perth.
http://www.public.health.wa.gov.au/cproot/1510/2/Health_Impacts_of_Climate_Change.pdf
- Department of Infrastructure and Planning 2010a. *South East Queensland Infrastructure Plan and Program 2010–2031* (SEQIPP), The State of Queensland, Brisbane.
<http://www.dlqp.qld.gov.au/resources/plan/SEQIPP/dip-seqipp-10.pdf>
- Department of Infrastructure and Planning 2010b. *Temporary State Planning Policy - TSPP 1/10*, The State of Queensland, Brisbane.
- Department of Infrastructure and Planning 2010c. *State Planning Policy 4/10: Healthy Waters*
- Department of Infrastructure and Planning 2003. *State Planning Policy 1/03: Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*: The State of Queensland, Brisbane.
- Department of Local Government and Planning 2011. *Climate Change Adaptation*, The State of Queensland, Brisbane. <http://www.dlqp.qld.gov.au/regional-planning/adaptation.html>
- Department of Planning and Local Government 2010. *30 Year Plan for Greater Adelaide*, Government of South Australia, Adelaide
- Department of Planning and Local Government 2009. *Port Pirie Structure Plan – Draft*. Government of South Australia, Adelaide.
<http://www.planning.sa.gov.au/index.cfm?objectid=37945ADE-F203-0D46-A222BD4AE1A9C19F>
- Department of Transport and Urban Planning 2007. *Planning Strategy for Regional South Australia* Government of South Australia, Adelaide
- Development Act 1993*, (Government of South Australia).

Development Regulations 2008, (Government of South Australia).

Draft Public Health Bill 2008, (Government of Western Australia)

Emergency Act 2005 (Government of Western Australia).

Emergency Management Regulations 2006 (Government of Western Australia)

Environmental Protection Act 1986 (Government of Western Australia)

Environmental Protection Agency (2005) *Wetland maps and data – Gladstone Regional Council*

<http://www.epa.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMapsAndData/SummaryInfo/LGA/>

Eyre Peninsula Local Government Association, Eyre Peninsula Natural Resource Management Board, Eyre Regional Development Board and Whyalla Economic Development Board 2010. *Eyre Peninsula Regional Sector Agreement Pursuant to the Climate Change and Greenhouse Emissions Reduction Act 2007 July 2010*. Government of South Australia, Adelaide.

http://www.climatechange.sa.gov.au/uploads/Sector%20Agreements/Eyre_Peninsula_Agreement.pdf

Fire and Emergency Services Authority of Western Australia Act 1998 (Government of Western Australia).

Garnaut Climate Change Review 2008. *Impact of climate change on infrastructure in Australia and CGE model inputs*, prepared by Maunsell Australia Pty. Ltd., in association with CSIRO Sustainable Ecosystems, June.

GHD 2009. *Report for Collie Urea Project - Public Environmental Review*. Prepared for Perdaman Chemicals and Fertilisers, Perth.

<http://www.perdaman.com.au/media/7487/sections%201%20and%202%20-%20introduction%20and%20project%20location.pdf>

Gladstone Health Community Council 2010. *Annual Report 2009/2010*

Gladstone Regional Council 2010a. *The Gladstone Region*.

<http://www.gladstone.qld.gov.au/web/guest/history>

Gladstone Regional Council 2010b. *The Region of Choice*.

<http://www.gladstone.qld.gov.au/web/guest/about-gladstone-region>

Gladstone Regional Council 2010c. *Local Disaster Management Plan*. November 2010. Local Disaster Management Group, Gladstone Regional Council

http://www.gladstone.qld.gov.au/c/document_library/get_file?uuid=82a51066-23b5-491b87b4-62356b80a06a&groupId=1570002

Gladstone Regional Council 2010d. *Factsheet: Tigalee Creek Project*. Community Relations section, Gladstone Regional Council

http://www.gladstone.qld.gov.au/c/document_library/get_file?uuid=c4344bec-455f4949-b5a6-82e489494c16&groupId=1570002

Gladstone Regional Council 2009. *Drought Management Plan*. October 2009. Infrastructure Services – Water & Sewerage, Gladstone Regional Council.

http://www.gladstone.qld.gov.au/web/guest/gladstoneairport?p_p_id=20&p_p_lifecycle=1&

[p_p_state=exclusive&p_p_mode=view&_20_strutsaction=%2Fdocument%2Fget_file&_20_folderId=2437523&_20_name=DLFE44399.pdf](#)

Government of South Australia 2010. South Australia State Emergency Service, http://www.ses.sa.gov.au/site/community_safety/floodsafe/flood_information.jsp#Whatisaflood

Government of South Australia, (n.d.). *South Australian Country Fire Service* http://www.cfs.sa.gov.au/site/about_us/glossary_of_terms/glossary_of_terms_to_h.jsp.

Health Care Act 2008, (Government of South Australia).

Health Care Regulations 2008, (Government of South Australia).

Health Act 1911, (Government of Western Australia).

Health Services Act 1991, (Government of Queensland),

Heim, R. 2002. A review of twentieth century drought indices, *Bulletin of the American Meteorological Society*, August, 1149-1165

Helman, P., Thomalla, F. and Metusela, C. 2010. *Storm tides, coastal erosion and inundation*. Report for the National Climate Change Adaptation Research Facility, Gold Coast, Australia. [http://www.nccarf.edu.au/sites/default/files/FINAL%204-Storm%20Tides\(1\).pdf](http://www.nccarf.edu.au/sites/default/files/FINAL%204-Storm%20Tides(1).pdf)

Henderson D. and Ginger J. 2008. Role of Building Codes and Construction Standards in Windstorm Disaster Mitigation. *The Australian Journal of Emergency Management* . Vol 23 No. 2:40-46. May.

IID 2007. *Caboolture Shire Natural Disaster Risk Management Study*, Institute for International Development. Prepared for the Caboolture Shire Council.

Integrated Planning Act 1997. (Government of Queensland).

IPCC 2007. Climate change 2007: The physical science basis. Geneva, Switzerland, *Intergovernmental Panel on Climate Change: 21*.

IPCC 2001. Climate change: The scientific basis. Geneva, Switzerland, *Intergovernmental Panel on Climate Change: 20*. John Wilson and Partners Pty Ltd 2004. *Griffin Area Flood Study*, Prepared for Pine Rivers Shire Council. October 2005. <http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/residents/Griffin-Area-Regional-Flood-Study.pdf> Local Government Association of South Australia and the LGA Mutual Liability Scheme (2010) *Local Government Climate Change Adaptation Program*, Interim Report May, Adelaide

McInnes, K. L., Suppiah, R., Whetton, P. H., Hennessy, K. J. & Jones, R. N. 2003. *Climate change in South Australia*: Report on the assessment of climate change, impacts and possible adaptation strategies relevant to South Australia.

Moreton Bay Regional Council 2011. *Moreton Bay Regional Council*. <http://www.moretonbay.qld.gov.au/>

Moreton Bay Regional Council 2008. *Planning Scheme Policy for the Pine Rivers Plan PSP17 Demonstrating Compliance with the Major Flood Events Overlay Code* <http://www.moretonbay.qld.gov.au/uploadedFiles/moretonbay/development/planning/pine-rivers/PSP17%20Demonstrating%20Compliance%20with%20the%20Major%20Flood%20Events%20Overlay%20Coded.pdf>

- Northern Adelaide and Barossa Catchment Water Board 2000. *Water Allocation Plan Northern Adelaide Plains Prescribed Wells Area*, Catchment Water Management Plan – Volume 3, Government of South Australia, Adelaide.
http://www.amlnrm.sa.gov.au/Portals/2/WAPs/nap_wap_july07.pdf
- Northern and Yorke Natural Resources Management Board 2009. *Northern and Yorke Regional NRM Plan. Volume A: State of the Region Report 2008*, Government of South Australia, Adelaide. <http://www.nynrm.sa.gov.au/Portals/7/pdf/INRM/A%20-%20NYNRM%20-%20State%20of%20the%20Region%20-%20FINAL%20-%20low-res.pdf>
- Nyrstar Limited 2010. *Port Pirie - 100% Nyrstar Lead and Zinc Smelting Operation*
http://www.nyrstar.com/nyrstar/en/operations_and_streaming/operations/australia/portpirie/
- OneSteel Ltd. 2010. *OneSteel Lifecycle Model* <http://www.onesteel.com/companystucture.asp>
- Planning and Development Act 2005*, (Government of Western Australia).
- Port Pirie Regional Council 2010a. *About Our Region*,
<http://www.pirie.sa.gov.au/site/page.cfm?u=119>
- Port Pirie Regional Council, 2010c. *Pirieodical*, July, p.3.
- Port Pirie Regional Council 2006. *Road Management Plan*,
http://www.pirie.sa.gov.au/webdata/resources/files/Road_Management_Plan.pdf
- Proctor, W., Cork, S., Langridge, J., Langston, A., Abel, N., Howden, M., Anderies, M, Parry, R & Shelton, D 2002. 'Assessing ecosystem services in Australia' in *Proceedings of 7th Biennial Conference of the International Society for Ecological Economics*, 6-9 March, Sousse, Tunisia
- Queensland Government 2009. *Climate Q: Toward a greener Queensland - Region summary – SEQ*, <http://www.climatechange.qld.gov.au/pdf/regionsummary-seq.pdf>
- Queensland University of Technology 2010. *Impacts and adaptation response of infrastructure and communities to heatwaves: the southern Australian experience of 2009*. Report for the National Climate Change Adaptation Research Facility, Gold Coast, Australia.
[http://www.nccarf.edu.au/sites/default/files/FINAL%205-Heatwaves\(2\).pdf](http://www.nccarf.edu.au/sites/default/files/FINAL%205-Heatwaves(2).pdf)
- Rights in Water and Irrigation Act 1914*. (Government of Western Australia)
- Seqwater 2010. *Strategic Plan 2010-11 to 2014-15*, Queensland Bulk Water Supply Authority, The State of Queensland, Brisbane.
<http://www.seqwater.com.au/public/sites/default/files/userfiles/file/pdfs/Seqwater2010-15%20Strategic%20Plan%20final.pdf>
- Standards Australia 2009. AS/NZS ISO 31000: 2009, Risk Management – Principles and Guidelines. <http://fraud.govspace.gov.au/files/2010/12/Australian-Standard-310002009.pdf>
- Sustainable Planning Act 2009*, (Government of Queensland).
- The Observer 2011. Weather may cut city power supply, *The Gladstone Observer*, Gladstone, 1 January.
- Tonkin Consulting 2005. *Port Adelaide Seawater Stormwater Flooding Study*,
<http://www.climatechange.gov.au/publications/coastline/~media/publications/coastline/5fsection517SA.ashx>

- Western Australia Health Department (d.u.), *Health impacts of climate change*, Government of Western Australia, Perth. http://www.public.health.wa.gov.au/cproot/1510/2/Health_Impacts_of_Climate_Change.pdf
- Warren, C 2010. The Facilities Manager Preparing for Climate Change Related Disaster. *Facilities*. Vol.28 No.11/12:502-513.
- Western Australia State Natural Resource Management Board 2010. *NRM for WA - A draft strategy for managing and using Western Australia's land, water and ecosystems*. http://www.nrm.wa.gov.au/docs/DRAFT_WA_NRM_Strategy_19May2010.pdf
- Western Australian Planning Commission 2010. *The Greater Geraldton Structure Plan update 2010*. Government of Western Australia, Perth. <http://www.planning.wa.gov.au/Plans+and+policies/Publications/2273.aspx>
- Western Australian Planning Commission 2009. *Local Planning Scheme No. 5 (Greenough)*, Government of Western Australia, Perth.
- Western Australian Planning Commission 2006a. *State Planning Policy 1 State Planning Framework Policy*, Government of Western Australia, Perth. <http://www.planning.wa.gov.au/Plans+and+policies/Publications/750.aspx>
- Western Australian Planning Commission 2006d. *Town Planning Scheme No. 1A (Greenough River Resort)* Government of Western Australia, Perth. <http://www.planning.wa.gov.au/The+planning+system/Region+schemes/Local+planning+schemes/513.aspx>
- Western Australian Planning Commission 2002. *Towards a Greater Geraldton*. Government of Western Australia, Perth. <http://www.planning.wa.gov.au/Plans+and+policies/Publications/55.aspx>
- Wildlife Conservation Act 1950*, (Government of Western Australia).



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