Balranald Shire Council

Increasing Resilience to Climate Change (IRCC) Project

Volume 2

Environmental and Social Baselines Report

December 2021

BSC is being assisted with this NSW Government Funded project by a Project Team from Management Solutions (Queensland) Pty Ltd, the Institute for Land Water and Society (ILWS) at Charles Stuart University (CSU) and the SEGRA Foundation.

ACKNOWLEDGEMENT OF COUNTRY

Council acknowledges the traditional Custodians of the lands and waters within our Shire and recognises their ongoing responsibility to care for Country and of teaching and learning.

We pay our respects to Elder's past, present and emerging and extend our respects to all Aboriginal and Torres Strait Islander First Nations Peoples.

Balranald Shire Council Increasing Resilience to Climate Change Project
Environmental and Social Baselines Report

PREFACE
First Nations Culture and Heritage Setting

The Balranald Shire Council *Increasing Resilience to Climate Change Project* aims to identify and pilot measures to mitigate the risk of increasing temperatures and variable rainfall under climate change to the provision of adequate and safe private domestic water supplies on rural and remote properties and for people using rainwater tanks in towns and settlements in the Shire.

Important lessons on adaptation and resilience in the face of the challenges of changing climatic conditions can be drawn from the over 40 000 years of utilisation of the land and the water resources by First Nations people on country that is now known as Balranald Shire. From the banks of the permanently flowing rivers and perennial lakes to the eroded dunes and lunettes of the desertified plains, evidence abounds of millennia of economic, cultural, and spiritual engagement by Aboriginal people including the Barkindji/Paakantji, Mutthi Mutthi and Ngiyampaa.

Westerway, Williams and Kelly (2021) point out that: *The ancestral remains from Willandra occupy a crucial place in understanding the dispersal of modern humanity across the globe and the story of our species' adaptation to climate change. Mungo Man and Mungo Lady have been dated to 42,000 years old, making them Australia's oldest human remains. Mungo Lady is the oldest known cremation in the world.* Most importantly, these remains are the source of the world's oldest human mitochondrial DNA (Bowler et al 2003). And Mungo Man and Lady coexisted with megafauna.

Niche Environment and Heritage (2015) reported that artefacts and remains have been well preserved among sediments in and around the beds of the region's major ancient lake systems. They also note that fossil records suggest an interaction of the Aboriginal population with an environment that underwent rapid change as the lakes responded to climatic changes and people adapted.

Water is fundamental to all forms of life. The spiritual value of water to First Nations people is a persistent theme, and there is an inextricable link between cultural and safe water (Pascoe 2018). The concerns of Aboriginal communities over the adequacy and quality of sources of their supplies are shared by many in the wider population of Balranald Shire and the region.

The World and National heritage values of the Willandra Lakes Region show that environmental and social baselines for Balranald Shire can be benchmarked by over 40 000 years of utilisation of the land and the water resources of country by First Nations people.

EXECUTIVE SUMMARY

The Balranald Shire Council Increasing Resilience to Climate Change Project aims to identify and pilot measures to mitigate the risk of increasing temperatures and variable rainfall under climate change to the provision of adequate and safe private domestic water supplies for people on rural and remote properties in Balranald Shire.

To attain this aim, Objective 2 of the project was: *To establish an 'environmental baseline' for domestic supplies on rural and remote properties.*

Pursuant to Australian legislation, the term environment is all encompassing and includes physical, biological, social, economic, cultural and heritage elements of the surroundings and activities of people. In this context, Objective 2 has been achieved by collating descriptive and mapped information on biophysical, socio-economic and climate change conditions and implications for Balranald Shire in its regional setting.

In summary, the 'environmental baseline' for domestic supplies on rural and remote properties in Balranald Shire is characterized by regional landscapes that biophysically reflect the effects of cyclic drying since the last ice age. Post European settlement, this trend has been exacerbated by periods of prolonged drought on land surfaces and drainage patterns modified for agriculture and pastoral use. In this setting, resilience and adaptions to climate change are benchmarked by the utilisation of this country by First Nations people as recorded by early explores and reflected in Pascoe (2018). And there are learnings to be had from linking cultural and safe water values to ensure scarce supplies are adequate and not a health risk.

Data and maps from AdaptNSW and CLIMsystems indicate that the projected impacts from changing climatic conditions reported by Sinclair Knight Merz (2010) are realistic and could affect community, business, and governmental activities. Specifically. there will be:

- less rainfall and water for extractive purposes for primary industry and human consumption
- higher rates of evaporation of surface water resources
- lower levels of soil moisture
- higher temperatures and greater health risks
- increased incidence of extreme weather events (prolonged droughts, floods, and bushfires)

Reduction in the availability, adequacy, and quality of water supplies from dams, bores and rainwater harvesting on private properties because of higher temperatures, lower rainfall along with increased evaporation and prolonged drought could constrain economic activities and adversely affect livelihoods and lifestyles in the Shire. Without property scale adaptive measures including treatment of groundwater sources there will be inadequate non-scheme water for household use. And rainwater supplies will need to be carefully conserved by householders through demand management and simple treatment processes to reduce health risks. Tools are available to enable householders to increase the reliability and quality of all sources of supply.

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1. INTRODUCTION

The Project

Balranald Shire Council (BSC) is undertaking the ***Climate Change Adaptive Private Domestic Water Supplies for Rural and Remote Properties*** project under the NSW Government Increasing Resilience to Climate Change (IRCC) program**.**

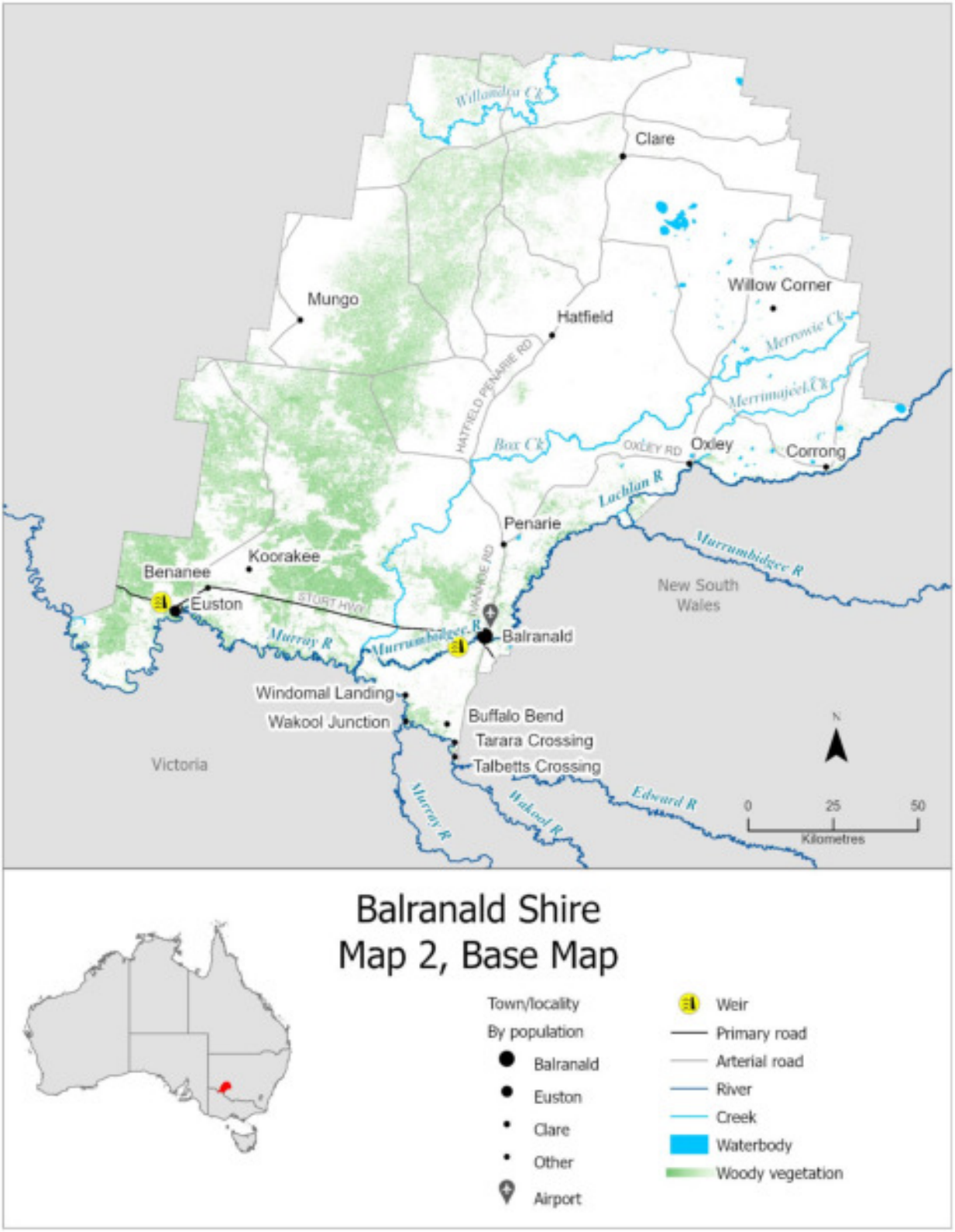
BSC gratefully acknowledge that this project is funded by the NSW Department of Planning, Industry and Environment and assisted by Local Government NSW.

The location

Balranald Shire (**Map 1**) is in the south-western district of NSW. The Shire is approximately 850km south-west from Sydney and 450km north of Melbourne and covers an area of approximately 21 400 square kilometres, making it the fifth largest Local Government Authority (LGA) in NSW.

Map 1. Location Balranald Shire NSW

Map 2 shows that the main townships are Balranald with a population at the 2016 Census of 1 343, and Euston with a population of 639. Respectively, they are located on the banks of the Murrumbidgee and Murray Rivers. Other localities in the Shire include Kyalite, Oxley, Penarie (Homebush), Hatfield and Clare. And at the 2016 Census about 156 people were living on rural properties outside the towns and settlements


Balranald Shire
Map 2, Base Map
Clare
Willow Corner
Mungo
Hatfield
Merrowie Ck
Merrimajeel Ck
Box Ck
Oxley
Corrong
Lachlan R
Penarie
Koorakee
Benanee
Euston
Balranald
Murrumbidgee R
New South Wales
Murray R
Windomal Landing
Wakool Junction
Buffalo Bend
Tarara Crossing
Talbetts Crossing
Victoria
Edward R
Wakool R
N
0
25
50
Kilometres
Town/locality
By population
Balranald
Euston
Clare
Other
Airport
Weir
Primary road
Arterial road
River
Creek
Waterbody
Woody vegetation

2.

Purpose of the baselines

Baselines encompassing biophysical and socio-economic conditions across the Shire have been established to provide a spatial and descriptive context for:

- projecting the possible effects of changing climatic conditions on:
    - production and conservation landscapes
    - natural surface drainage patterns and aquifer recharge zones
    - the adequacy and quality of surface and ground water sources
    - rural population distribution and commercial enterprises
    - accessibility of households to surface and underground water sources

- analysing responses of householders to the questionnaire survey with respect to existing and potential sources of surface and ground water supplies used on rural and remote properties

- reviewing the vulnerability of people on farms and grazing properties to possible health risks from poor quality water supplies

- proposing actions to increase resilience at the property scale and ensuring that household supplies are secure and safe

Approach to establishing the baselines

Public base maps and satellite images have been used to produce a combination of vector (point, polyline, and polygonal) and raster (imagery and gridded data) layers to illustrate and summarise regional physical, biological, social, and cultural features for stakeholder communication and reporting. Metadata for the layers is listed at **Annex A.**

Spatial information layers for the IRCC Project cover:

- Locational attributes:

    - geographic extent of the Shire in a state-wide context
    - relationship with major centres nearby
    - towns, villages, and settlements
    - road network and airfields
    - key areas of cultural and historic significance

- Landform and landscape features highlighting:

    - key geomorphic elements (rivers, wetlands, floodplains, ephemeral lake systems, drylands)
    - drainage patterns

- Vegetation assemblages encompassing:

  - riverine and wetland vegetation
  - woody vegetation
  - dryland and saltpan vegetation

- Land uses including:

  - irrigated and dryland cropping
  - irrigated and dryland grazing
  - forest and conservation reserves
  - water storage infrastructure

A generalised distribution of private water resources has been mapped and provides:

- simplified location and boundaries of properties to ensure privacy is protected
- schematic representation of water sources and storage infrastructure using symbols (surface supplies, bores, and rainwater tanks)

The responses to the 2020-21 Shire wide questionnaire survey and 'do-it-yourself' testing of household supplies provides benchmarking information on sources of household supplies, levels of consumption and treatment, and personal attitudes towards the water being used.

Baseline socio-economic conditions are benchmarked circa 2009-2010 using material from reports held by BSC. They include:

- Balranald Shire Council (2012) *Economic Development Strategy: Sustaining our Region for a Productive Future*, Balranald NSW.
- Balranald Shire Council (2020a) *Community Development Plan (CDP)*
- Balranald Shire Council (2020b) *Community Strategic Plan (CSP) 2020-2040*
- RMCG (2010) *Balranald Shire Council, Hay Shire Council Wentworth Shire Council, Key trends and drivers of change in water availability and Future water availability sce*narios, Melbourne.
- Sinclair Knight Merz (2010) *Strengthening Basin Communities Stage 1 Studies Socio-Economic Status Study – Balranald Shire.*
- Toohey, D (2010) Tourism Scoping Study for Balranald Including Feasibility of an Interpretative Centre
- Wentworth Shire Council (2010) *Strengthening Basin Communities Project, Community Report,* prepared on behalf the Balranald Shire Council, Hay Shire Council and Wentworth Shire Council Consortium.

This approach enables a timeframe to be established for examining the effects of projected climatic changes on sources and quality of non-scheme water supplies in Balranald Shire.

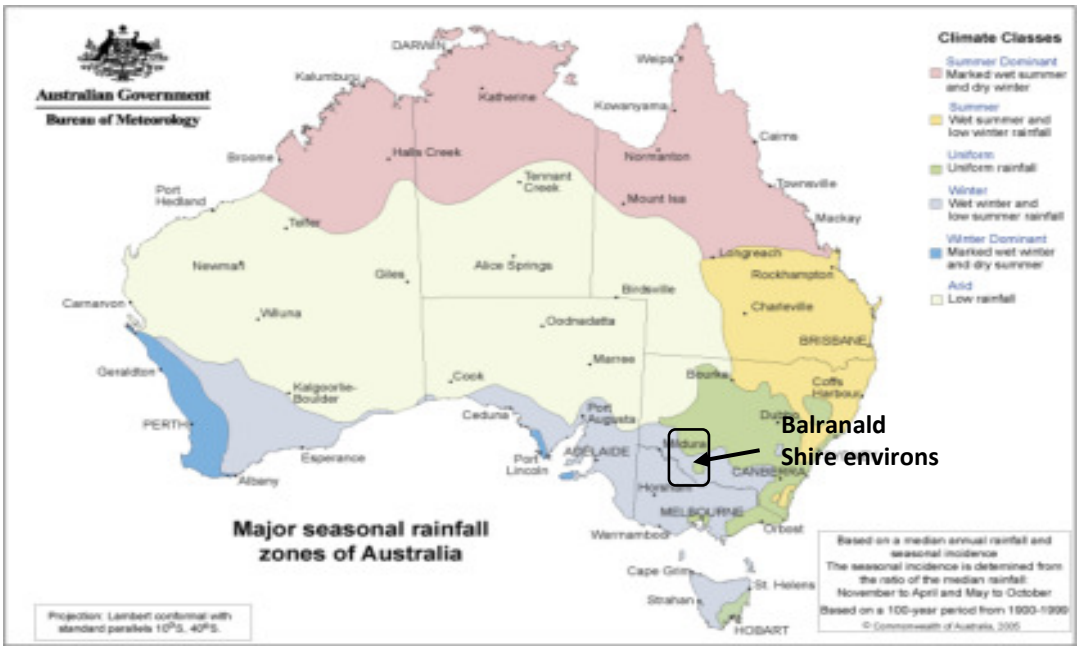
2. BIOPHYSICAL CONDITIONS

Climate

Bureau of Meteorology (BoM) daily weather and seasonal climatic data is available for BALRANALD (RSL), site number 049002 (Latitude 34.64 S; Longitude 143.56 E; Elevation 61m). Records commenced in 1879 and the station is classed by BoM as open with all data current. Statistical data (tables and graphs) can be access through: Climate statistics for Australian locations (bom.gov.au); and Balranald climate, averages and extreme weather records (weatherzone.com.au).

The present-day climate much of Balranald Shire is classed as semi-arid. Climate data show an average maximum day-time temperatures in January of 33°C, with an average minimum temperature in July 15.7°C. Average monthly rainfall ranges between 22.1 mm to 31.5 mm and is consistent throughout the year (averaging approximately 325 mm per annum). The monthly average evaporation exceeds the monthly average rainfall for much of the central to northern part of the Shire. Time series rainfall data from BoM for Robinvale-Euston, Balranald and Ivanhoe in **Figure 1** illustrates the variability in rainfall from South to North (http://reg.bom.gov.au/climate/averages/tables/cw_049002.shtml).

Map 3 indicates that the Shire has two identifiable Climate Classes. One is characterised by having a wet winter and low summer rainfall and the other uniform rainfall. Seasonal rainfall across the Far West of NSW is extremely variable. There have been extended droughts since before the end of the 20th Century accompanied by persistent heatwave conditions.

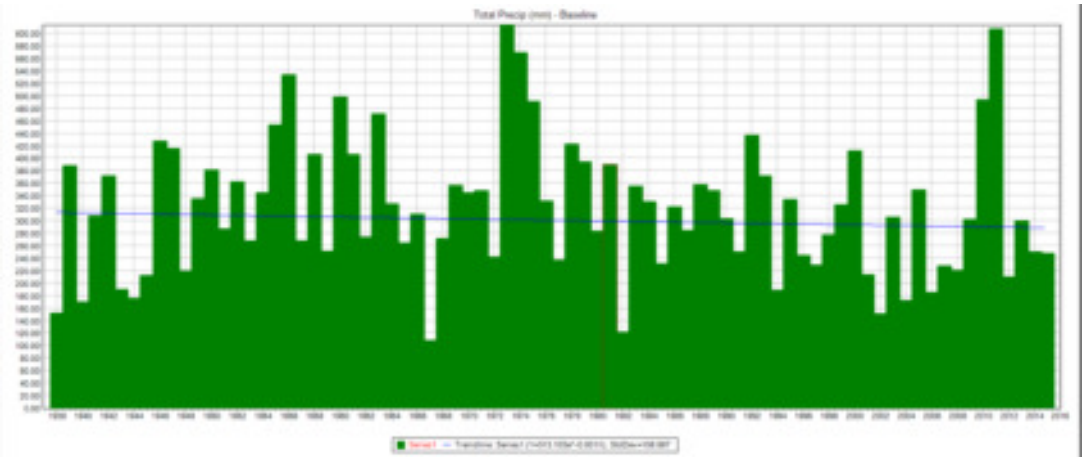


Map 3. Climate Classes

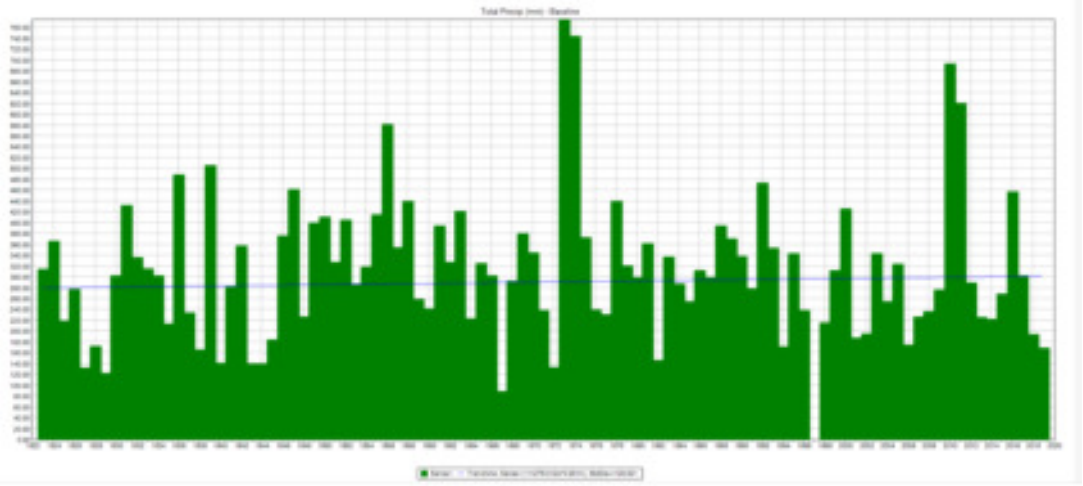
Figure 1. Historic BoM rainfall time series Robinvale-Euston, Balranald & Ivanhoe

Robinvale-Euston

Balranald



Ivanhoe



Topography and bioregionalisation

The topography of Balranald Shire is shown on **Map 4**. The Shire has been described as 'a geographer's living classroom' (Toohey, 2010). Biophysically, it displays the features of two great Australian landscapes: to the east the Riverine Plain; and to the west the Murray Darling Depression (Toohey, 2010). At some 60 metres above sea level, the climatic, geomorphic and soil formation processes have produced a distinctive vegetation collage.

Topographically, Balranald Shire is part of two major bioregions: the Murray Darling Depression; and the Riverina. Bioregions are large, geographically distinct areas of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities. Environment Australia (2000) describes the Murray Darling Depression and the Riverina in the Interim Biogeographic Regionalisation for Australia (IBRA) and indicates their importance for the delineation of protected areas.

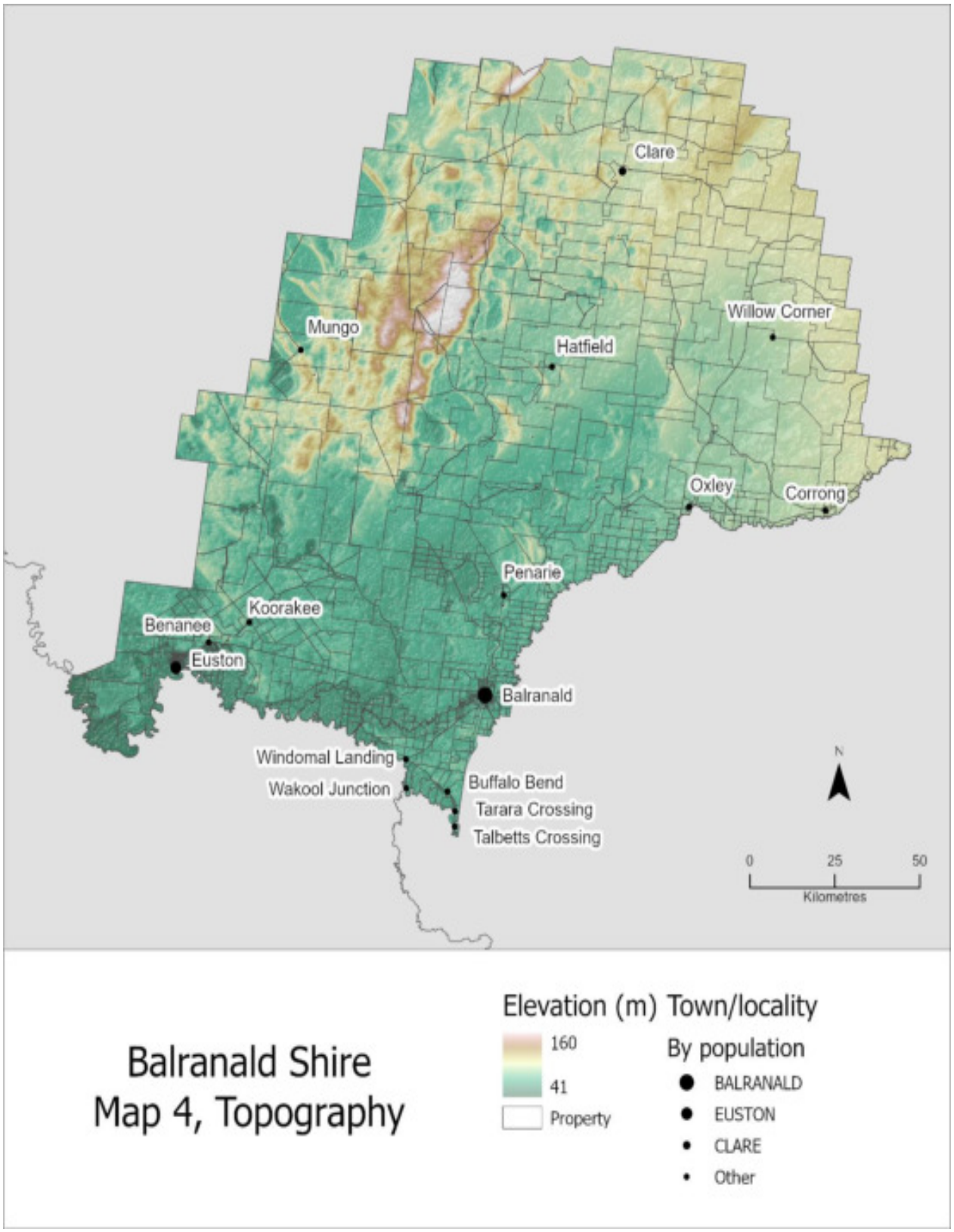
Much of the Shire is characterised by dune fields and sand plains vegetated by mallee communities, and brown soil undulating plains usually vegetated by saltbush, bluebush, belah and rosewood communities. Also conspicuous are swamp depressions, small ephemeral lakes, and a system of a series of large relict lakes and fringing lunette formations.

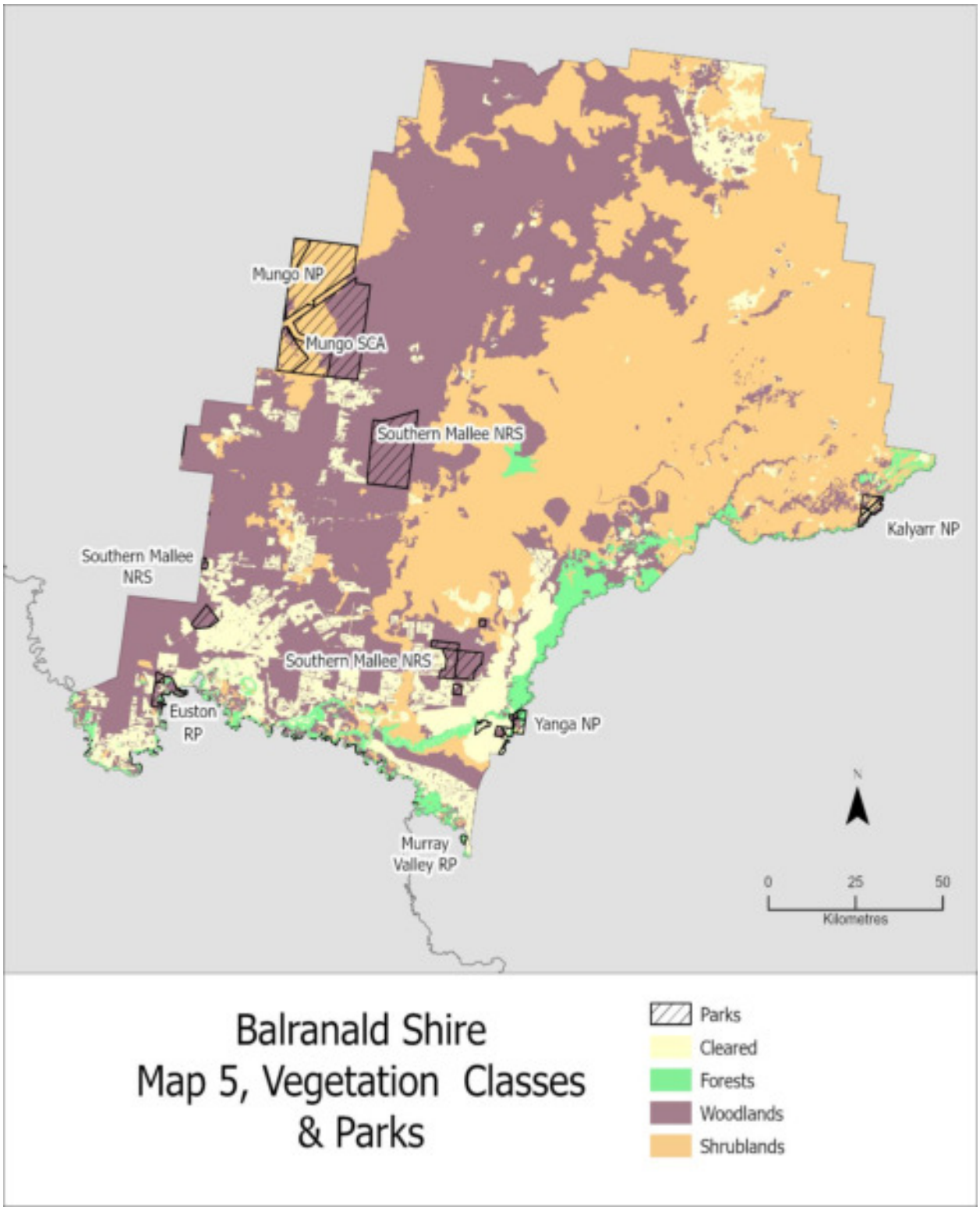
Vegetative cover and protected areas

Map 5 shows that the vegetation classes are complex and include woodlands, shrublands, riverine forests and inland floodplain swamps. The spatial extent of key classes is listed in **Table 1**.

Table 1. Areas (hectares) and Percent of Total of key Vegetation Class

Vegetation Class	Area (hectares	Total	Percent of Total
Aeolian Chenopod Shrublands	330,732		15.3
Inland Floodplain Shrublands	92,206		4.3
Riverine Chenopod Shrublands	532,070		24.6
Shrublands Total		**955,008**	44.1
Dune Mallee Woodlands	237,279		11.0
Inland Floodplain Woodlands	91,662		4.2
Inland Rocky Hill Woodlands	792		0.0
Riverine Sandhill Woodlands	9,556		0.4
Sand Plain Mallee Woodlands	196,621		9.1
Semi-arid Sand Plain Woodlands	364,387		16.8
Woodlands Total		**900,298**	41.6
Inland Riverine Forests	64,965	**64,965**	3.0
Cleared	244,233	**244,233**	11.3
Total	2,164,503	**2,164,503**	100.0


Clare
Mungo
Hatfield
Willow Corner
Oxley
Corrong
Penarie
Koorakee
Benanee
Euston
Balranald
Windomal Landing
Wakool Junction
Buffalo Bend
Tarara Crossing
Talbetts Crossing
N
0
25
50
Kilometres
Balranald Shire
Map 4, Topography
Elevation (m)
160
41
Property
Town/locality
By population
BALRANALD
EUSTON
CLARE
Other


Mungo NP
Mungo SCA
Southern Mallee NRS
Kalyarr NP
Southern Mallee NRS
Southern Mallee NRS
Euston RP
Yanga NP
Murray Valley RP
N
0
25
50
Kilometres
Balranald Shire
Map 5, Vegetation Classes & Parks
Parks
Cleared
Forests
Woodlands
Shrublands

Water resources and their management

Map 6 shows the distribution of natural sources and water storage infrastructure. Across the Shire there are 612 dams, 58 bores and 489 tanks. Also, there are weirs to the southwest of Balranald on the Murrumbidgee River and near Euston on the Murray River.

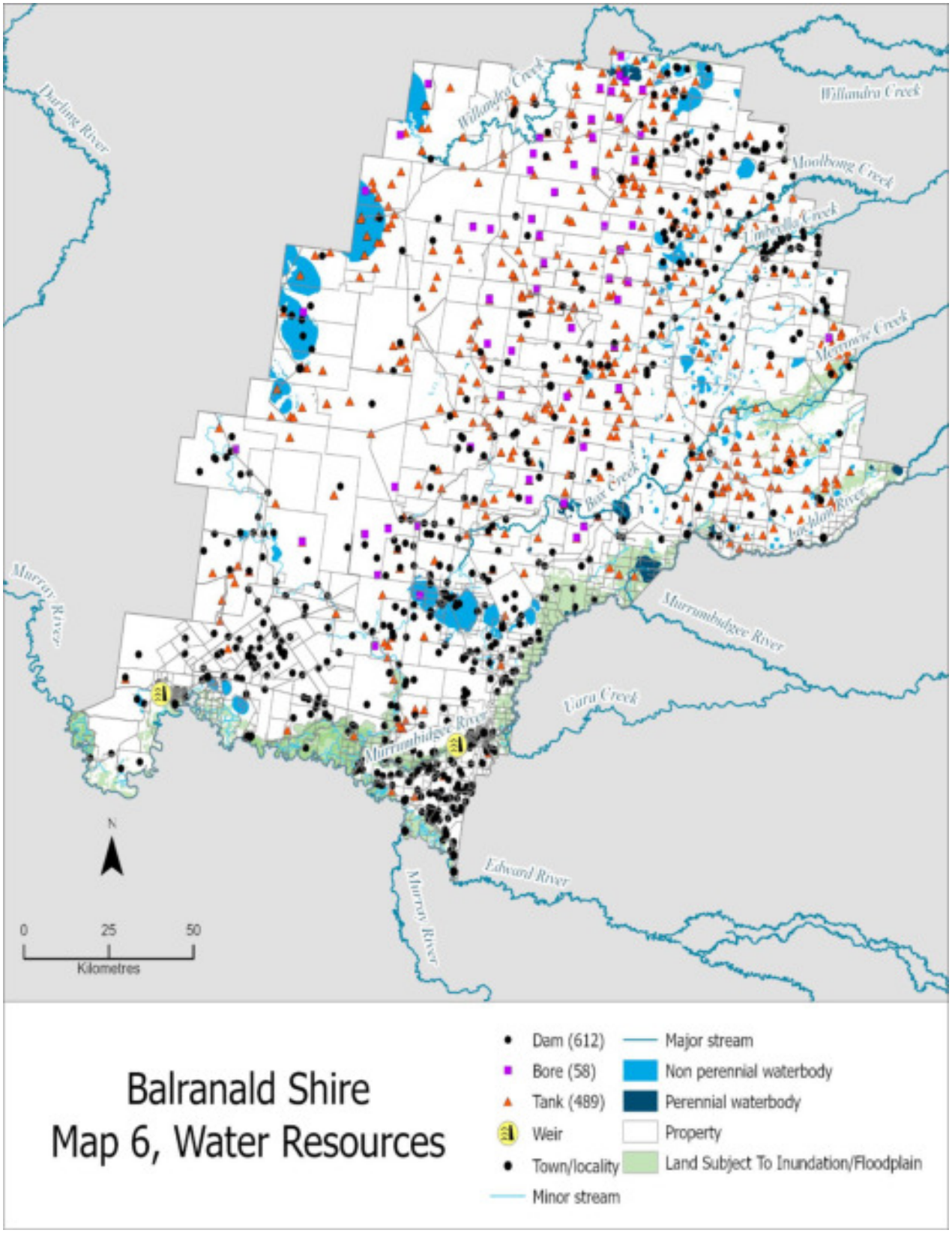
To put the water management situation for people on rural and remote properties across the Shire into perspective, Australia wide little assistance is provided by any level of government to ensure either adequacy of supply or to reduce potential health risks from non-scheme water. In all Australian jurisdictions, Local Governments only have statutory responsibility for the quantity and quality of scheme water provided to rural cities, towns, and settlements. People on farming and pastoral properties are left to their own devices to secure domestic water sources. This inequity could be considered a serious gap in policy and practice when aiming to ensure that all Australians have adequate and safe household water supplies.

Broadly, the water resources of the Shire (surface and ground) are addressed by the Murray Darling Basin Authority (MDBA) through the Murray-Darling Basin Plan (the Basin Plan) that was passed into law in November 2012. The plan aims to balance social, economic, and environmental demands on the Basin's water resources, to ensure there are:

- Strong and vibrant communities with sufficient water of a suitable quality for drinking and domestic uses (including in times of drought), as well as for cultural and recreational purposes
- Productive and resilient industries that have long-term confidence in their future, particularly for food and fibre production
- Healthy and diverse ecosystems with rivers regularly connected to their creeks, billabongs and floodplains, and ultimately the ocean

At the heart of the Basin Plan is the need to increase the amount of water for the environment of the Murray Darling Basin and ensuring sufficient water for all users. To achieve this balance, the Basin Plan reduces the amount of water that can be taken from the rivers by setting sustainable diversion limits (SDLs) for both surface water and groundwater for each catchment area in the Basin.

Critical human water needs are defined in subsection 86A (2) of the Water Act 2007 and Chapter 11 of the Basin Plan and cover all uses of surface and ground water for domestic purposes. Essential first steps towards understanding how this statutory requirement is met at the property scale include: raising awareness of potential health risks; water quality screening; and providing information on remedial actions to reduce the impacts of poor quality domestic water supplies. As promulgated, the Basin Plan is about water allocation for irrigators and other users and environmental flows in the main arteries of the catchments, below dams. The MDBA has developed a Climate Workplan that will *steer effort from 2021 to 2026, to work towards a sustainable, productive, and resilient Murray–Darling Basin under a changing climate.*


Darling River
Willandra Creek
Willandra Creek
Moolbong Creek
Limbrella Creek
Merannie Creek
Bus Creek
Murray River
Murrumbidgee River
Uara Creek
Murrumbidgee River
Edward River
Murray River
N
0
25
50
Kilometres
Balranald Shire
Map 6, Water Resources
Dam (612)
Bore (58)
Tank (489)
Weir
Town/locality
Minor stream
Major stream
Non perennial waterbody
Perennial waterbody
Property
Land Subject To Inundation/Floodplain

Rural and remote household water supplies

Objective 2 of the project required that: *Within six months, to provide: a quantitative inventory of sources of supply and infrastructure at risk from changing climatic conditions; and qualitative information on attitudes and behavior of householders towards health risks.* The requirements of this Objective were delivered by the questionnaire survey and accompanying water screening for coliforms, and the water resources map and text in this environment baseline. The questionnaire survey applied to domestic water use only and was focused on private supplies on rural and remote properties and rainwater tanks in Balranald and Euston. For the survey, domestic water means tap water supplied via plumbing fittings to homes for drinking, washing, cooking, laundry, sanitation, and other household uses.

One hundred and six properties with contact details were found and attempts were made to contact all by either email or telephone. A total of 51 surveys were submitted. This represents a 48% response and statistically this is a satisfactory result. Twenty 'do-it-yourself' kits were requested for water testing. Using the submitted surveys as the baseline, 39% of the respondents participated in screening for bacteria. Again, statistically this is a satisfactory result.

The survey was commenced in September 2020 and initial findings were provided in Status Report 01/21 in January 2021. The survey instrument and the responses are at **Annex 3-D** in **V 3**, and the BSC Project Data Base.

Key findings of the BSC questionnaire survey

1. Daily consumption of water for domestic purposes

Data provided by respondents shows that:

- 34 percent use more than 200 litres per day
- 27.5 percent 100-199 litres
- 38 percent 10-99 litres
- 0.5 percent less than 10 litres

The size of household didn't correlate to the amount of water used, although this was a trend.

2. Domestic water sourced by household

- Roofs and stored in tank for future use 87%
- Surface water 55%
- Shallow groundwater 0%
- Deep groundwater 20%
- Carted supply 13%

Twenty-five percent had more than one source of supply for domestic water. Of the returned questionnaires, 39 (87 per cent) had rainwater tanks and 33 responded to the security of the water source as follows:

- *88% had animal droppings on the roof*
- *48.5% had trees overhanging the roof*
- *27% had aerial spraying occurring on nearby lands*
- *Only 18% had first flush devices installed*

3. Domestic water sourced by household from surface water drawn from rivers, creeks and dams which may or mayn't be stored in a tank prior to use

Twenty-six (55 %) of the 47 respondents used surface water and 52% stored their water in a tank and 44% did not. Thirty six percent reported that the intake was distant from septic tanks and 3 (12%) respondents, reported the surface water was restricted from livestock.

4. Domestic water sourced by household from deep groundwater drawn from bores, wells or springs that are greater than 20 metres deep which may or may not be stored in a tank prior to use

Only 40 respondents answered this question and of these 8 people 20 %, used deep ground water. Of these 40 respondents (9 people) responded as follows:

- 89% bore was distant from septic tanks and that the bore cover was secure
- 78% each offered that (a) the bore was protected from contaminated seepage from rubbish or agricultural run-off (b) stored in a tank
- 55% reported that water was stored in a tank,
- 55.5% reported that bore was restricted from livestock
- 22 % that it was not stored in a tank before use in house

5. Domestic water sourced by household from carted supply transferred by tanker and stored in a tank prior to use

39 respondents answered and only 5 people (13 %) used carted water. *(Of the people that used carted water 84.5% reported the tanker hose appears clean and does not come into contact with water in the tank, and 33.5% reported that the tanker is purpose built and maintained for drinking water transportation)*

6. Type of storage tank by household

Forty-three of the respondents answered this question and of these 32 (75 %) have above ground tanks with the top sealed and 6 (14 %) have above ground tanks that are not sealed. One respondent had below ground tanks and four respondents (10 %) reported no tanks at all.

7. Water treatment for domestic water by household

Seventy-seven percent of the 43 properties who responded to this question reported that their water was untreated. Thirty percent (13 respondents) indicated that their water was filtered. One property reported that they boiled the water that was used for drinking and cooking purposes. And one property used technology to treat their water.

8. Concern about quality of water

When asked to rank concern about quality of water (where 1 is highly concerned and 10 is not at all concerned) 9 respondents (20 %) showed that they were not at all concerned with a rating of 10 out of 10. Twenty-one per cent (10 respondents) rated their concern at 8-9. (ie 41 % ranked between 8 and 10). At the other end of the scale a total of 10 respondents (21%) ranked their concern at 1-3.

Of those 33 respondents using untreated water:

- 9 were concerned (identified as a ranking of 1-4)
- 5 identified a neutral position on concern
- 16 were not concerned (ie. identified no concern with a ranking of 6-10)

Presence of bacteria in private household supplies

Twenty 'do-it-yourself' water testing kits were provided to householders to screen the water that they use for drinking and cooking for coliforms. Fifteen to rural properties and five to residents in Balranald and Euston who used potable water from rainwater tanks. Seventeen results were returned, and they showed that over 60% of the tanks tested had bacteria in the water. This finding is expected to prevail for all rainwater tanks in the Shire.

3. SOCIO-ECONOMIC CONDITIONS

Establishing a context

The 2020 BSC *Community Strategic Plan* (CSP) noted that since 1849, when Lands Commissioner McDonald named Balranald after his Scottish birthplace, the town's existence has been maintained and reinforced over time through the importance of its river crossing, as a port, and transport and haulage location. With the continuing importance of the Sturt Highway; and the emergence of Lake Mungo National Park, Balranald has obtained a traveller 'stop-over' and haulage industry identity.

The CSP goes on to say that Balranald was proclaimed a town in 1851 then gazetted a municipality in 1882. The punt stock-crossing on the Murrumbidgee River was replaced by the first river bridge of the new municipality in 1888 and the arrival of the rail line from Victoria (via Echuca) in 1926.

In 1956, the municipality became the Shire of Balranald, and it shares boundaries with Central Darling (north), Murray River Council (south), Hay (east) and Wentworth (west). As shown in **Map 2** the Murray River forms the southern boundary and the Murrumbidgee and Lachlan flank the eastern margins of the Shire.

With its origins as a remote sheep station, Euston slowly evolved to be a proclaimed town in 1885. In 1924 the railway reached Robinvale on the Victorian side of the Murray River. The road bridge linking the two towns, built in 1928, secured Euston's economic future near the intersection of the Murray Valley and Sturt Highways. Both Balranald and Euston are situated on the Sturt Highway and have easy access to the nearby Victorian centres of Swan Hill and Mildura.

Balranald has a sealed airstrip, an established hospital, dentist, two schools and an early learning centre. The town has well-maintained parks and gardens, good sporting facilities and is a busy retail and commercial centre. Euston is a vibrant community, which is in a growth area of the Shire. Expansion of viticulture has occurred predominately in this area. The township boasts one of the finest clubs in the region.

Making a benchmark statement, the 2020 BSC CSP says:

> *Looking forward twenty years, we aspire to see continuing development of the Balranald Shire economy, steady improvements to its social fabric, and greater respect for and management of our environment. With five rivers designating the Shire's southern boundary, water is and will be influential in this scenario.*

Culturally, the Shire is rich in both Indigenous and non-Indigenous history. Mungo National Park, which is part of the world heritage listed Willandra Lakes region, is primarily located in Balranald Shire (Map 2). The Park has areas of global archaeological significance with evidence of human occupation dating back at least 50 000 years.

South-western NSW was settled by Europeans from the late 1840s. In this historical context, Balranald Shire has important sites showcasing pastoral industry, inland port heritage and colonial built infrastructure. And the Shire is viewed as being exceptionally asset rich in terms of community, economic, environmental, and cultural resources (Balranald Shire Council 2012).

Population characteristics

The 2020 BSC CSP noted that total population has slowly but steadily declined from 2 751 in 2001 before rising to 2 338 in 2016, an overall decrease of 15.0%. The small positive numbers were net overseas migration reflecting work opportunity, and births over deaths. The 2020 CSP reported that at the 2016 Census the population was:

- 51.4% male
- 48.6% female
- 8.8% Aboriginal and/or Torres Strait Islander people
- 27% children aged 19 years and under
- 28% young adults (20 to 44)
- 45% older adults (45 years and over)

The CSP reports that the most common ancestries in Balranald Shire were Australian 32%, English 25%, Irish 10 %, Italian 9%, and Scottish 6%. Some 82% of people were born in Australia compared with 66% for Australia in total. The CSP also notes that Balranald residents have a strong sense of community with over 30 % of the community participating in voluntary work in 2016.

Table 2 provides a summary comparison of selected population characteristics for Balranald, Hay, Murray, Wentworth, and Swan Hill Shires. There are conspicuous similarities in the structural elements of the regional population in terms of (for example) median age, personal income, dwellings owned outright, household size and vehicles per household. For example, Balranald has the largest household with 3.0 and the largest number of children per household with 2.1. **Table 2,** the following socio-economic parameters differentiate Balranald in its regional context:

- A median age which is younger than adjoining NSW councils
- The highest median wage and personal income in the group
- The second lowest median mortgage, implying that disposable income is higher than in neighbouring councils
- Outright ownership of dwelling is less than Murray and greater than Swan Hill
- Weekly rent is comparatively low
- Household sizes are a little greater, including Aboriginal and Torres Strait Islanders
- Slightly higher proportion of children and lower home internet access

Table 2. Summary of population characteristics for Balranald, Hay, Murray, Wentworth, Swan Hill Shires

Selected Population Characteristics	Balranald	Hay	Murray	Wentworth	Swan Hill
Median Age	40	43	47	42	40
Median wage per annum	42,027	38,410	40,962	31,623	38,137
Median personal income	624	587	558	462	580
Median monthly mortgage	950	982	1300	888	1,130
Dwelling owned outright %	41.3	41.1	44.5	38.3	36.8
Median weekly rent	150	150	200	170	185
Average household size	2.5	2.3	2.3	2.0	2.4
Average household size (ATI)	3.0	2.8	2.7	2.4	2.4
Average motor vehicles	1.9	1.9	1.9	1.6	1.9
Children per family	2.1	1.9	1.9	1.9	2.0
Internet accessed dwelling %	67.7	63.4	73.2	72.5	71.2

Source: Australian Bureau of Statistics Quick Stats 2016

Table 3 shows that the Shire had a very consistent median age over the five-year period 2014–2018. The slight variations with females a little older may be due to the number of young single males employed in the Shire.

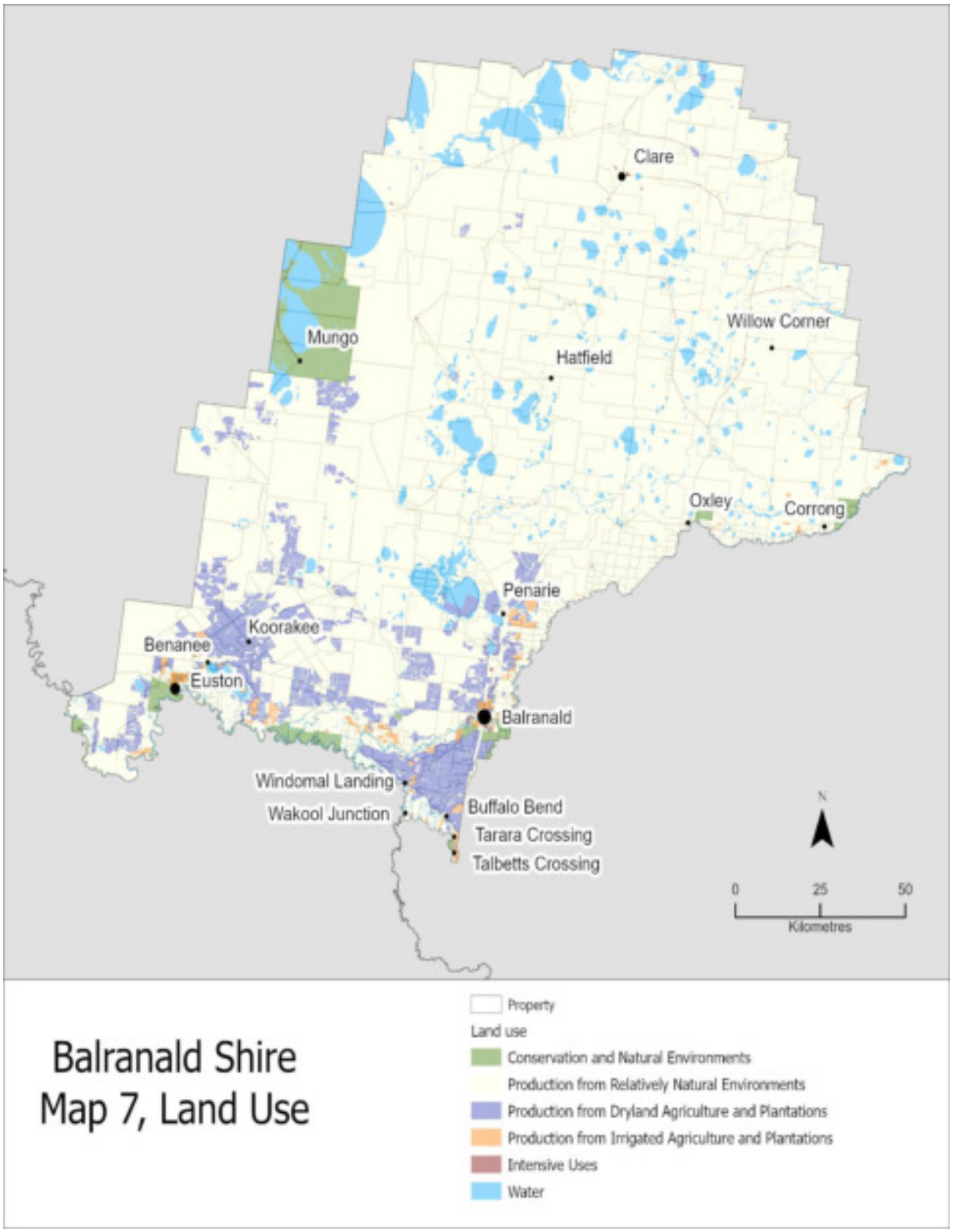
Table 3. Median Ages Balranald Shire

Median Ages (years)	2014	2015	2016	2017	2018
Males	40.3	39.2	39.8	39.9	39.8
Females	39.1	38.5	40.4	40.5	40.3
Persons	39.8	38.7	40.2	40.3	39.9

Source: Australian Bureau of Statistics, Table 10300 as extracted from the BSC 2020 CSP

Land uses

Map 7 shows the spatial pattern of land uses and properties for Balranald Shire. Key land uses in the Shire are summarised in **Table 4** and compared to the adjoining LGAs (Wentworth and Hay). In common with these LGAs, the economy of Balranald Shire is strongly connected to agriculture (Wentworth Shire Council 2010). This encompasses grains (dryland and irrigated) and grazing (sheep and cattle). However, diversification has occurred to encompass horticulture, viticulture, organic agriculture, tree (fruit and nut), timber harvesting and tourism. The Sturt Highway (**Map 2**) provides the east west route for flow of goods, services, and visitors to the Shire.



The areas of the key classes of land use shown in **Map 7** are summarised in **Table 5.**

Table 4. Land Use-----Balranald, Hay and Wentworth Shires 2010

Land Use	*Balranald Shire*		*Hay Shire*		*Wentworth Shire*	
	Ha	*%*	*Ha*	*%*	*Ha*	*%*
Degraded land	*9,537*	*0.4%*	*1,481*	*0.1%*	*36,837*	*1.40%*
Dryland – cropping	*74,482*	*3.4%*	*4,150*	*0.4%*	*55,413*	*2.10%*
Dryland – grazing	*1,974.640*	*91.0%*	*997,037*	*87.9%*	*2,198,175*	*83.80%*
Forestry	*10,092*	*0.5%*	*2,537*	*0.2%*	*14,301*	*0.50%*
Irrigation and drainage channels	*1,052*	*0.0%*	*14,041*	*1.3%*	*52*	*0.00%*
Irrigation – cropping	*3,738*	*0.2%*	*42,908*	*3.8%*	*653*	*0.00%*
Irrigation- grazing	*3,902*	*0.2%*	*7,368*	*0.6%*	*1,406*	*0.10%*
Irrigation – perennial horticulture	*1,978*	*0.1%*	*73*	*0.0%*	*9,654*	*0.40%*
Irrigation- seasonal horticulture	*244*	*0.0%*	*406*	*0.0%*	*486*	*0.00%*
Natural environments	*64,113*	*3.0%*	*37,499*	*3.3%*	*273,458*	*10.40%*
Other uses	*1,018*	*0.0%*	*2,598*	*0.2%*	*2,492*	*0.10%*
Transport	*3,958*	*0.2%*	*3,829*	*0.3%*	*5,093*	*0.20%*
Water – rivers and wetlands	*21,849*	*1.0%*	*19,990*	*1.8%*	*26,488*	*1.00%*
Total	*2,170,603*		*1,134,918*		*2,624,508*	

Source: Table 5: Wentworth Shire Council (2010) Strengthening Basin Communities Project, Community Report.
Data Source: Bureau of Rural Sciences
Note: Land use areas are in ha. Other uses include a variety of urban and commercial purposes

Table 5. Summary of Key Classes of Land Use by Area (hectares)

Land Use Class	Area	Percent of Total Area
Conservation and Natural Environments	59,755	2.8
Production from Relatively Natural Environments	1,770,274	81.6
Production from Dryland Agriculture and Plantations	151,369	7.0
Production from Irrigated Agriculture and Plantations	16,159	0.7
Intensive Uses	3,156	0.1
Water	168,289	7.8
Total	**2,169,002**	100.0

In 2010 the consortium led by Wentworth Shire Council reported that agriculture is the largest industry in the three shires by land use, employment, and value of production. A current trend is the expansion of high value irrigated horticultural production, which is underpinned by secure access to water from the Murray River. There are opportunities for the expansion of high value agriculture in the Shire. These opportunities need to be promoted to attract investment.

Wentworth Shire Council (2010) also argued that opportunities for further growth will be subject to ongoing secure access to water. Thus, it is essential that certainty is provided to farmers and potential investors through the implementation of the Murray Darling Basin Plan. And this need and its socio-economic implications are still to be dimensioned and tested.

While dryland agriculture accounts for almost 90% of the region's primary industry, the farming economy is dominated by irrigation. Only about 1.2% of the total area of land across the three shires is used for irrigated agriculture. However, in 2005-2006 the outputs from this land accounted for about 67% of the gross value of agricultural production (Wentworth Shire Council 2010).

The significance of irrigation is greatest in the Wentworth Shire, which holds the largest number of high security irrigation entitlements. In 2005-06, irrigation in Wentworth Shire accounted for over 80% of the gross value of agricultural production. At the same time, it accounted for 66% of the gross value of agricultural production in Hay Shire and 47% of the value of production in Balranald Shire. Wentworth Shire Council (2010) reported that a total regional value of irrigated agricultural production was approximately $162M in 2000-01 and approximately $192M in 2005/06. This represents estimated average values of production of $372/ML and $616/ML of irrigation allocation.

Dry climate in recent years and low irrigation water allocations have affected some forms of irrigation production in the region. For example, as reported by Wentworth Shire Council (2010), irrigated land use was estimated to have contracted significantly in each of the Shires. Specifically, irrigation in Hay Shire was estimated to have contracted by almost 80% from over 50,000ha in about 2004. This change was due to reduction in water licences held in the Shire. The impacts of changing climatic conditions are still to be qualitatively assessed.

Industry and Employment

Table 6 is taken directly from Wentworth Shire Council (2010) and provides a regional comparison of the industry and employment sectors within Balranald, Hay and Wentworth Shires. At that time, primary industry was the most important sector followed by retail, health care and social assistance and then education and training. Tourism is a significant industry in the Shire and Far West Region. Wentworth Shire Council (2010) reported that it contributed $7.0M/annum. Growth in tourism will increase economic diversity and reduce the region's reliance on agriculture and water dependent industries. A strategic adaptive approach is required to manage this growth in areas that are biophysically vulnerable to climate change.

Aged and Health Care

Balranald Shire has an ageing population and over many years suffered from declining health services (Wentworth Shire Council 2010). Balranald currently has suitable aged care and health care facilities, and there is potential to expand service delivery and utilise the new multipurpose health centre for training of health professionals. Existing aged and health care services in Balranald Shire have the potential to provide ongoing necessary services and to retain and attract retirees to the area.

The health services sector offers good employment opportunities and any growth in this area will contribute to the ongoing economic development in the Shire and region. This is an important factor to consider when looking at the resilience of the sector with respect to the challenges of changing climates.

Table 6. Top 10 Industry and Employment Sectors within Balranald, Hay and Wentworth Shires in 2010

Sector	Balranald Shire		Hay Shire		Wentworth Shire		Region	
	%	Rank	%	Rank	%	Rank	%	Rank
Agriculture, forestry and fishing	31.6%	1	27.5%	1	24.2%	1	26.6%	1
Retail	8.8%	2	10.1%	2	8.3%	2	8.8%	2
Health care and social assistance	7.7%	4	7.4%	5	7.1%	5	7.3%	3
Education and training	8.4%	3	7.3%	6	6.5%	7	7.1%	4
Accommodation and food services	5.2%	7	8.0%	4	7.2%	3	7.0%	5
Construction	4.9%	9	5.6%	7	6.9%	6	6.1%	6
Public administration and safety	6.0%	5	8.7%	3	4.5%	8	5.9%	7
Manufacturing	5.1%	8	3.3%	10	7.2%	3	5.8%	8
Transport, postal and warehousing	5.7%	6	3.9%	8	4.1%	9	4.4%	9
Wholesale trade	2.9%	10	2.9%	11	4.1%	10	3.5%	10

Note: % is the percentage of the workforce employed in the top 10 employment sectors for the whole region. Source: Australian Bureau of Statistics: 2006 Census community profile series

Minerals and energy

Illuka Resources Limited hold two rutile-rich deposits (Balranald and Nepean) north of Balranald. Owing to their relative depth, Iluka is assessing the potential to develop these deposits using innovative underground mining technology. Trials have been undertaken to determine the economic feasibility of the technology, confirm the effectiveness of the underground mining method, and validate key elements of the mining unit design.

Two solar photovoltaic plants are sited between Balranald and Kyalite. They are the Sunraysia Solar Farm that is owned and operated by the Australian firm Maoneng, and the German owned Limondale Solar Farm. The solar characteristic of the Shire offers considerable opportunity for similar enterprises.

Tourism, recreation, and Aboriginal heritage

Located on the Sturt Highway approximately halfway between Sydney and Adelaide and 440 km northwest of Melbourne, Balranald is a gateway to 'Outback NSW'. Perched on the Murrumbidgee River, the town is surrounded by land and riverscapes which include the world heritage listed Mungo National Park and the wetlands of Yanga National Park. The area boasts spectacular fauna as well as heritage sites such as the Yanga Wool Shed and the Yanga Homestead. Several historic buildings of the former port are now incorporated into the town's Heritage Park, including the start of the town's Heritage Walk.

Rivers and creeks meander and converge within the Shire. This waterscape of vegetated banks and floodplains is a major ecological and aesthetic feature. At the southwest corner of the lower Murrumbidgee floodplain, the Balranald Common Bird Trail has remnant black box, red gum, and lignum vegetation habitats. And the Murrumbidgee, Murray, Lachlan, Wacool and Edward rivers make the Shire an ideal destination for fishing, camping, boating, canoeing, kayaking or just 'chilling out' on the banks.

More than 30 years ago the largest collection of modern human remains from the last glacial cycle outside of Africa was unearthed at the Willandra Lakes World Heritage Area (Bowler et al 2003) located northwest of Balranald (see **Map 5**). Aboriginal occupation of the area extends back at beyond 50,000 years, and their dead were buried in the sand dunes. The area records evidence of the oldest funeral ceremonies recorded in the world, cremating, and then covering the deceased with powdered ochre. The traditional owners of the land include the Mutthi Mutthi, Paakantji and Ngiyampaa people (See http://visitbalranald.com.au/heritage-culture). Some 40 000 years ago at the height of the last 'Ice Age' the area abounded with a diverse assemblage of terrestrial and aquatic fauna. Agriculture and aquaculture was practiced by First Nation people (Pascoe 2018). Today it is a parched semi desert landscape that attracts visitors from around Australia and the world. At the centre of this series of dry lake beds is Mungo National Park. One of the features of the park is an eroded silcrete formation that was named the 'Walls of China' by early Chinese workers who built dams and woolsheds for early pastoralists.

Bowler et al (2003) reported stratigraphic evidence from the Pleistocene lakebed indicates fluctuations between lake-full and drier conditions from 50 to 40 thousand years ago. This occurred simultaneously with increased dust deposition, human arrival, and continent-wide extinction of the megafauna. This was followed by the on-set of sustained periods of aridity continuing to the present. This new chronology corrects previous estimates for human burials at this important site and provides a new picture of *Homo sapiens* adapting to deteriorating climate in the world's driest inhabited continent (Bowler et al 2003).

Ecological implications of drying landscapes: the 'frog story'

The Southern Bell Frog is strongly identified with Balranald and frog sculptures can be found around the town, including outside the Visitor Information Centre. This species is on the New South Wales Endangered Species list.

The Southern Bell Frog (*Litoria raniformis*), also known as the Growling Grass Frog because of the sound of its call, is closely related to the Green and Golden Bell Frog and is found in semi-permanent wetlands. Once widespread and abundant its distribution in the State it is now restricted to a few areas along the Murrumbidgee and the lower Murrumbidgee floodplain around Balranald. Changing climatic and hydrological conditions are having a major impact on these riverine habitats.

Cross-border considerations

Balranald and Euston have cross-border neighbouring communities; Swan Hill and Robinvale, separated only by the Murray River (the NSW and Victorian state border). These townships are conjoined like suburbs with employment, services (especially health), commerce and infrastructure provided each side of the river and utilised by people regardless of the state in which they reside.

Beyond that, there are service and education links to Bendigo and Ballarat (Victoria), along with empirical inclination to visit Melbourne for a wide range of reasons (Balranald Shire Council 2020).

The region's phone numbers have the Victorian (03) prefix and the now-defunct rail lines were part of the Victorian network. This is an historic socio-economic relationship that has demographic implications in terms of the dynamics of the regional population.

The 2020 Balranald Shire Council Community Development Plan (CDP) makes the point that 'the Covid pandemic has seriously highlighted that the importance and reality of cross-border issues should not be ignored'. The argument is made that they need to be recognised as having a profound impact on local economies and the daily lives of businesses and residents. And this situation is most important when assessing the resilience of rural and town communities to the potential health risk from poor quality private water supplies due to changing climatic conditions.

4. CHANGING CLIMATIC CONDITIONS

Projected Climatic Changes

Contextualising information on climate change is available from:

- NSW weather and climate, see the *Bureau of Meteorology*
- How the major climate drivers affect NSW, see *Climate Kelpie*
- An animation of the major climate drivers in NSW, see *Climatedogs*

Examples of projected changes to climatic conditions presented at a regional scale from 2009 to 2079 in **Maps 8-15**. These show seasonal changes in temperature (max, min), rainfall (summer, winter), number of days exceeding 35 degrees centigrade. This material has been sourced from AdaptNSW link Far-West Climate change downloads https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Far-West-Climate-Change-Downloads.

Additional benchmarking material can be sourced from:

- Climate systems https://climatechange.environment.nsw.gov.au/About-climate-change-in-NSW/Climate-systems
- Climate change https://climatechange.environment.nsw.gov.au/About-climate-change-in-NSW/Understand-climate-change
- Climate change nationally https://www.climatechangeinaustralia.gov.au/en/

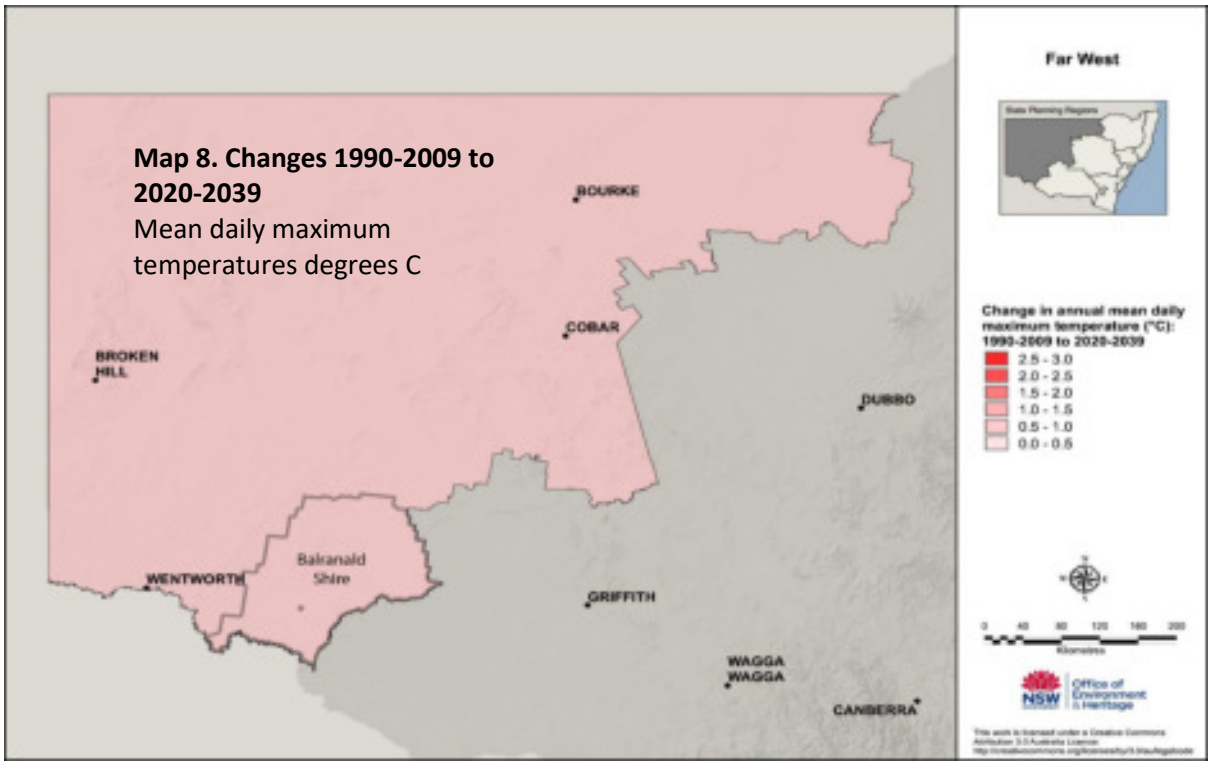
The projected changes shown on **Maps 8-15** are as follows.

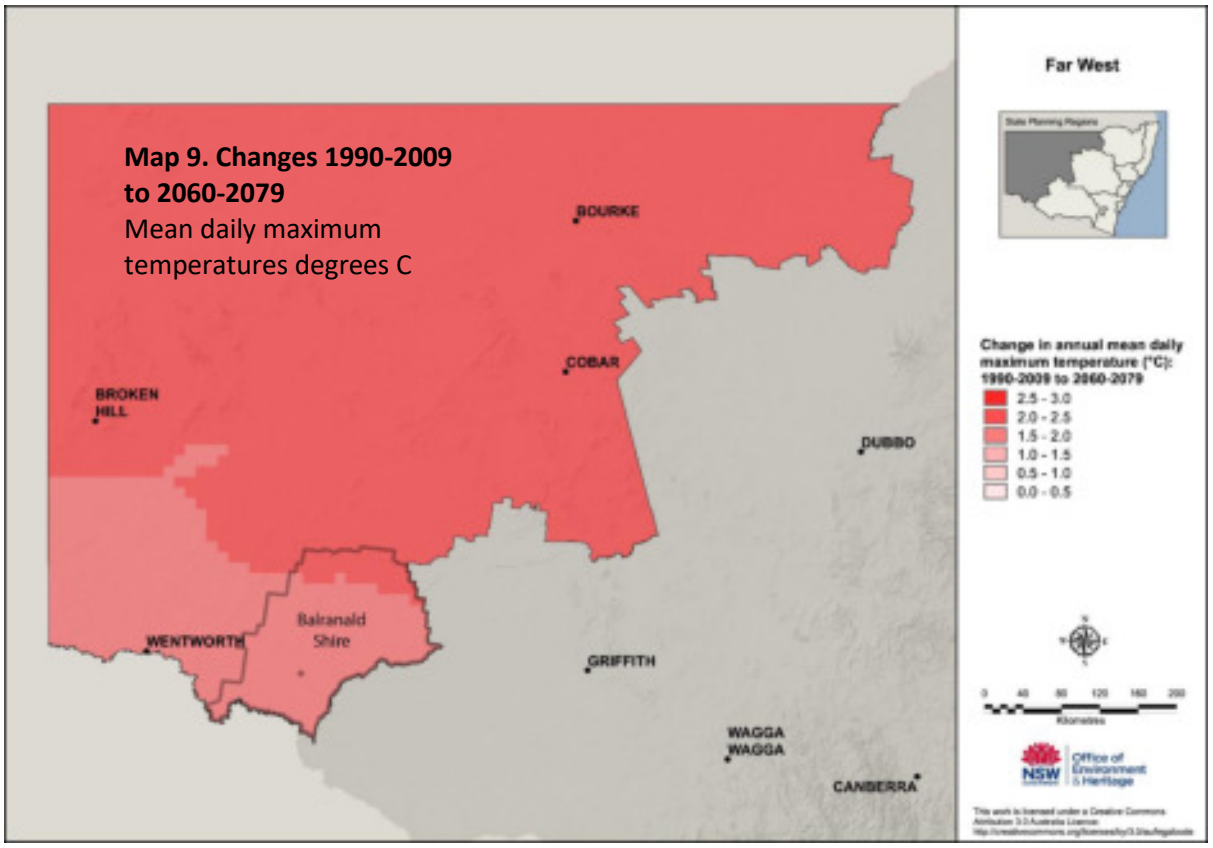
<u>Temperature</u>

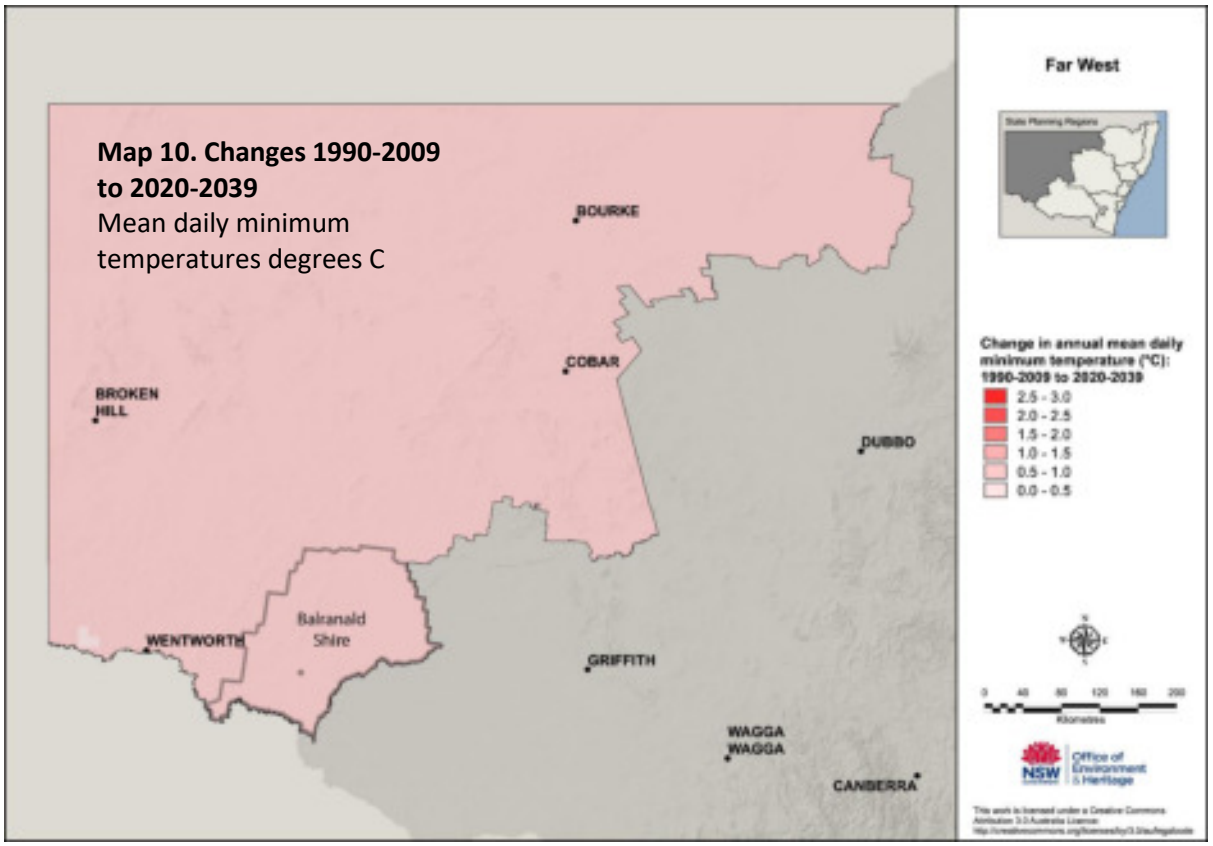
Map 8. Changes 1990-2009 to 2020-2039	
Mean daily maximum temperatures	0.5 to 1.0^{0}C
Map 9. Changes 1990-2009 to 2060-2079	
Mean daily maximum temperatures	1.0 to 1.5^{0}C
Map 10. Changes 1990-2009 to 2020-2039	
Mean daily minimum temperatures	0.5 to 1.0^{0}C
Map 11. Changes 1990-2009 to 2060-2079	
Mean daily minimum temperatures	1.5 to 2.0^{0}C
Map 12. Changes 1990-2009 to 2020-2039	
Mean number of days with temperatures greater than 35 degrees C	5 to 10 days
Map 13. Changes 1990-2009 to 2060-2079	
Mean number of days with temperatures greater than 35 degrees C	20 to 30 days

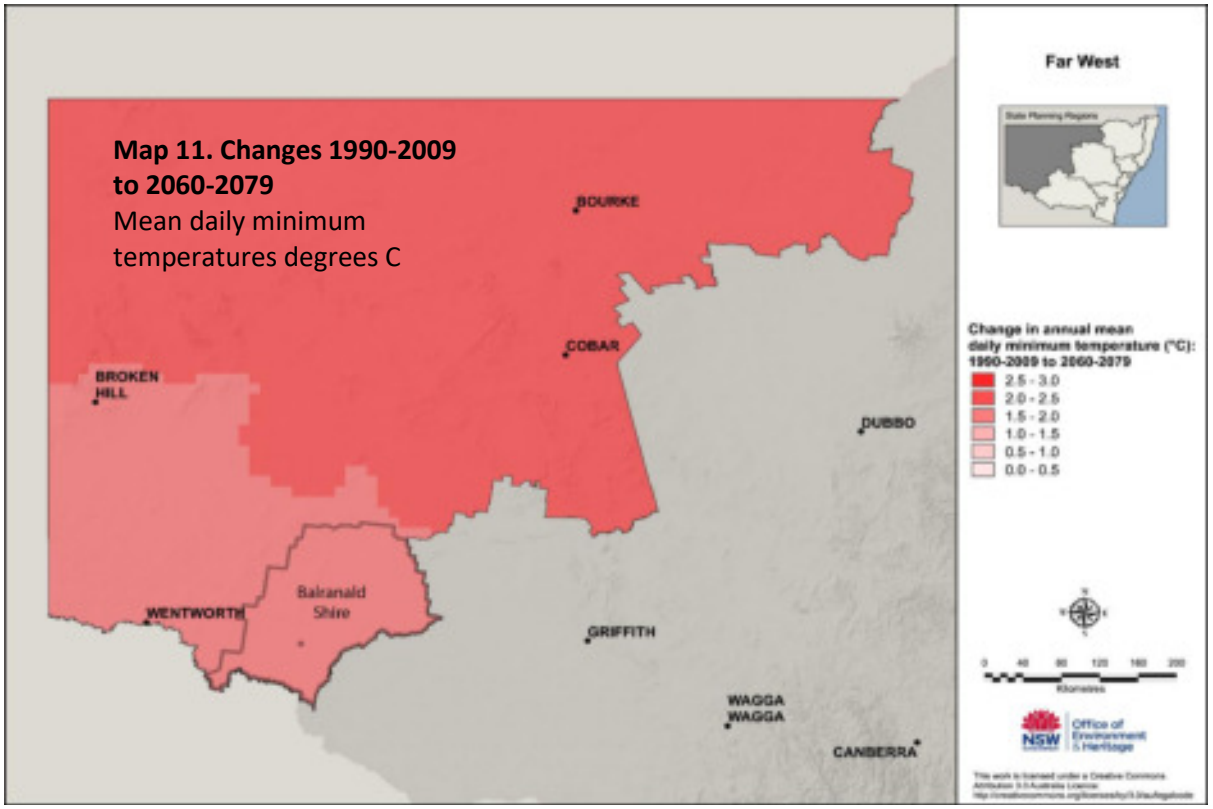
<u>Precipitation</u>

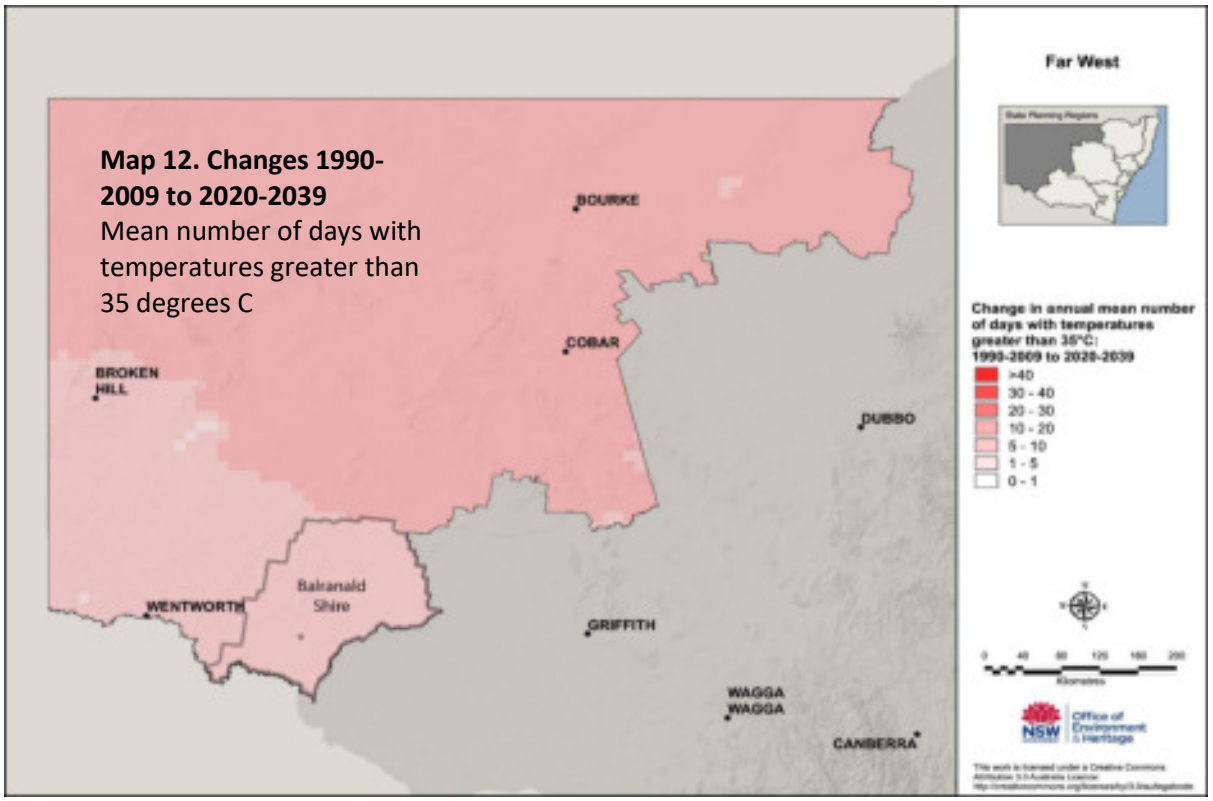
Map 14. Changes 1990-2009 to 2020-2039	
Mean annual precipitation from South to North	Between 0 to –5% and 0 to +5%
Map 15. Changes 1990-2009 to 2060-2079	
Mean annual precipitation from South to North	Between 0 to +5% and 5 to +10%

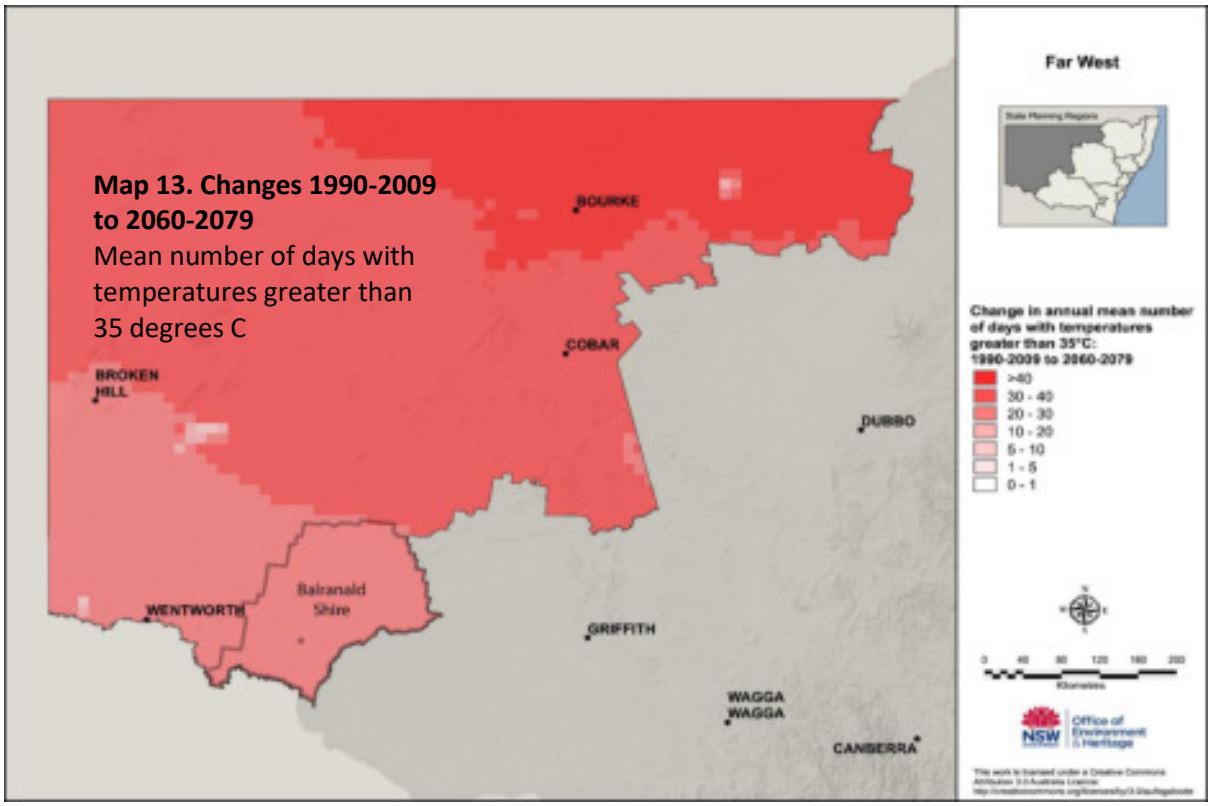

Map 8. Changes 1990-2009 to 2020-2039
Mean daily maximum temperatures degrees C
BOURKE
COBAR
BROKEN HILL
DUBBO
Balranald Shire
WENTWORTH
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean daily maximum temperature (°C): 1990-2009 to 2020-2039
2.5 - 3.0
2.0 - 2.5
1.5 - 2.0
1.0 - 1.5
0.5 - 1.0
0.0 - 0.5
Office of Environment & Heritage

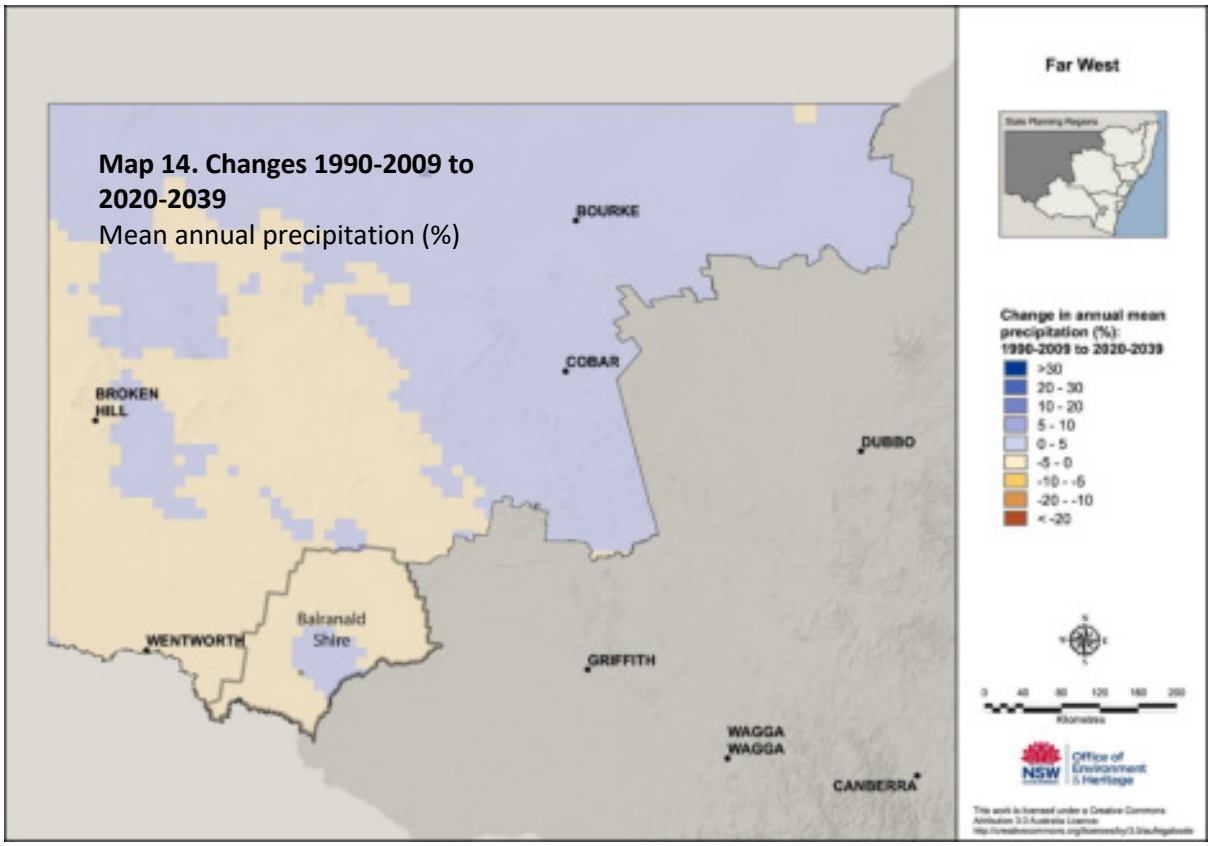

Map 9. Changes 1990-2009 to 2060-2079
Mean daily maximum temperatures degrees C
BOURKE
COBAR
BROKEN HILL
DUBBO
Balranald Shire
WENTWORTH
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean daily maximum temperature (°C): 1990-2009 to 2060-2079
2.5 - 3.0
2.0 - 2.5
1.5 - 2.0
1.0 - 1.5
0.5 - 1.0
0.0 - 0.5
Office of Environment & Heritage

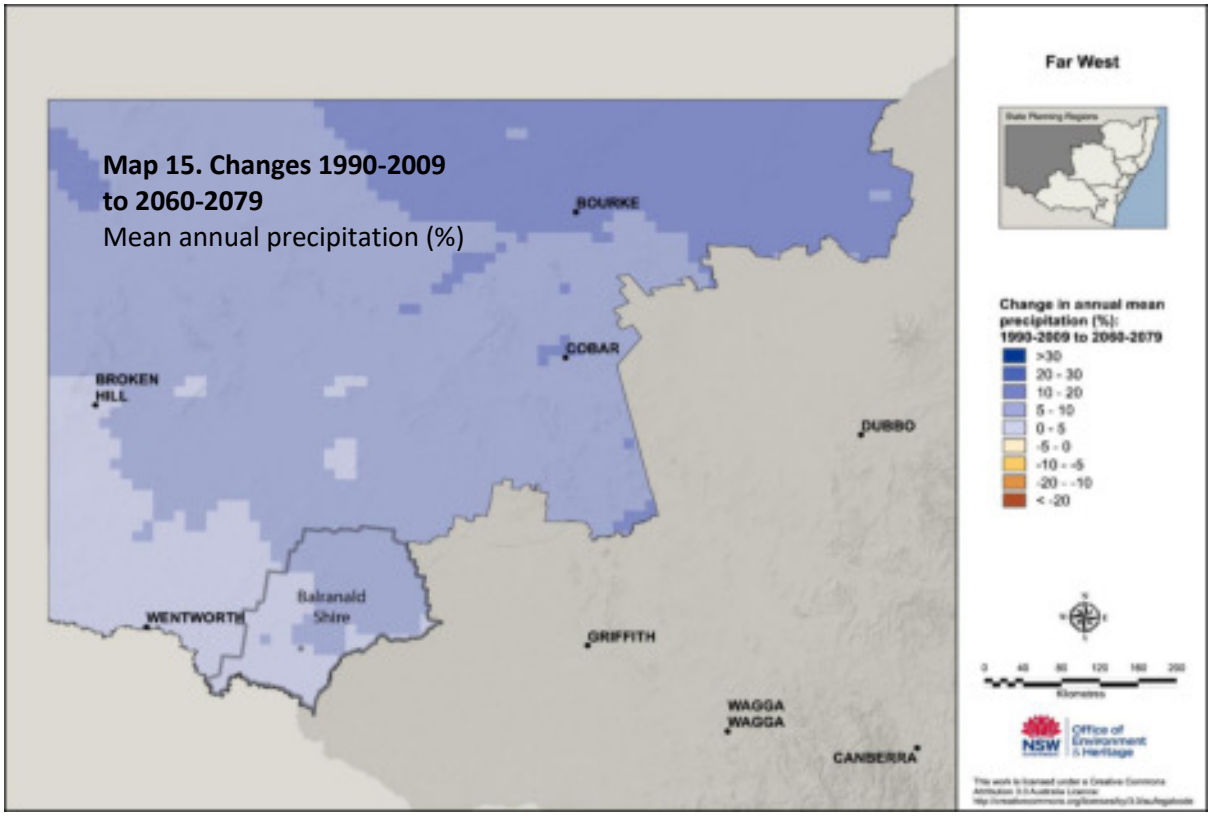

Map 10. Changes 1990-2009 to 2020-2039
Mean daily minimum temperatures degrees C
BOURKE
COBAR
BROKEN HILL
DUBBO
WENTWORTH
Balranald Shire
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean daily minimum temperature (°C): 1990-2009 to 2020-2039
2.5 - 3.0
2.0 - 2.5
1.5 - 2.0
1.0 - 1.5
0.5 - 1.0
0.0 - 0.5
Office of Environment & Heritage


Map 11. Changes 1990-2009 to 2060-2079
Mean daily minimum temperatures degrees C
BOURKE
COBAR
BROKEN HILL
DUBBO
WENTWORTH
Balranald Shire
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean daily minimum temperature (°C): 1990-2009 to 2060-2079
2.5 - 3.0
2.0 - 2.5
1.5 - 2.0
1.0 - 1.5
0.5 - 1.0
0.0 - 0.5
Office of Environment & Heritage


Map 12. Changes 1990-2009 to 2020-2039
Mean number of days with temperatures greater than 35 degrees C
BOURKE
COBAR
BROKEN HILL
DUBBO
Balranald Shire
WENTWORTH
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean number of days with temperatures greater than 35°C:
1990-2009 to 2020-2039
>40
30 - 40
20 - 30
10 - 20
5 - 10
1 - 5
0 - 1
Office of Environment & Heritage


Map 13. Changes 1990-2009 to 2060-2079
Mean number of days with temperatures greater than 35 degrees C
BOURKE
COBAR
BROKEN HILL
DUBBO
Balranald Shire
WENTWORTH
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean number of days with temperatures greater than 35°C:
1990-2009 to 2060-2079
>40
30 - 40
20 - 30
10 - 20
5 - 10
1 - 5
0 - 1
Office of Environment & Heritage


Map 14. Changes 1990-2009 to 2020-2039
Mean annual precipitation (%)
BOURKE
COBAR
BROKEN HILL
DUBBO
Balranald Shire
WENTWORTH
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean precipitation (%): 1990-2009 to 2020-2039
>30
20 - 30
10 - 20
5 - 10
0 - 5
-5 - 0
-10 - -5
-20 - -10
< -20
Office of Environment & Heritage


Map 15. Changes 1990-2009 to 2060-2079
Mean annual precipitation (%)
BOURKE
COBAR
BROKEN HILL
DUBBO
Balranald Shire
WENTWORTH
GRIFFITH
WAGGA WAGGA
CANBERRA
Far West
Change in annual mean precipitation (%): 1990-2009 to 2060-2079
>30
20 - 30
10 - 20
5 - 10
0 - 5
-5 - 0
-10 - -5
-20 - -10
< -20
Office of Environment & Heritage

CLIMsystems projections

The DPIE climate change baseline for the Far West region has been updated to provide 2021 picture for Balranald Shire. **Annex 3-G** in **Volume 3** is a set of climate change projections for mean annual, maximum, and minimum temperatures and mean annual rainfall for Balranald Shire for 2050, 2070 and 2090. This demonstration exercise was undertaken by the New Zealand company CLIMsystems with the software package SimCLIM that uses the latest CMIP5 climate data to generate maps, graphs, and charts of various aspects of climate change spatially and for sites. These provide a finer resolution for mapping than the AdaptNSW seasonal projections released by NARCLiM in 2014.

SimCLIM applies a pattern scaling approach for monthly precipitation changes, with high ensemble confidence intervals. This approach produces a consistent climate change signal to indicate a decrease or increase with global mean temperature change. **Figures 2** and **3** illustrate Shire scale SimCLIM demonstration mapping for baselines and projected 2070 changes for temperature and precipitation.

The SimCLIM result differs from the NARCLiM 2014 projections for **Map 14** (2020-2039) that indicates decreasing precipitation while **Map 15** (2060-2079) indicates increasing rainfall. SimCLIM runs a large ensemble of models and has a more statically consistent outcome and shows overall decline in annual precipitation from North to South for the Shire.

A reality check using the applied trend lines in **Figure 1** (p 6) shows no indication of any change in the historical patterns that would support a 10 per cent increase in rainfall. Based on over 100 years of highly variable rainfall data for Robinvale-Euston, Balranald and Ivanhoe lead to the conclusion that there is no possibility of significant increases in precipitation for the Shire in the coming decades.

Table 7 is a summary of SimCLIM Projections for Balranald Shire using SSP2-4.5 (left column) and SSP5-8.5 (right column) models showing:

- Average Seasonal and Annual Mean Temperature Baseline (Celsius) and Changes (Celsius)
- Average Seasonal and Annual Maximum Temperature Baseline (Celsius) and Changes (Celsius)
- Average Seasonal and Annual Minimum Temperature Baseline (Celsius) and Changes (Celsius)
- Average Seasonal and Annual Precipitation Baseline (mm) and Changes (%) - 50th Percentile

The updated projections and analysis of historical trends in annual rainfall Robinvale-Euston, Balranald and Ivanhoe confirm that temperatures will increase, and rainfall will decrease across the Shire. This has implications for developing adaptive measures to increase resilience to changing climates and ensuring that water supplies on rural and remote properties are adequate and safe.

Figure 2: Balranald, Average Seasonal and Annual Mean Temperature Baseline (Celsius) and Changes (Celsius).

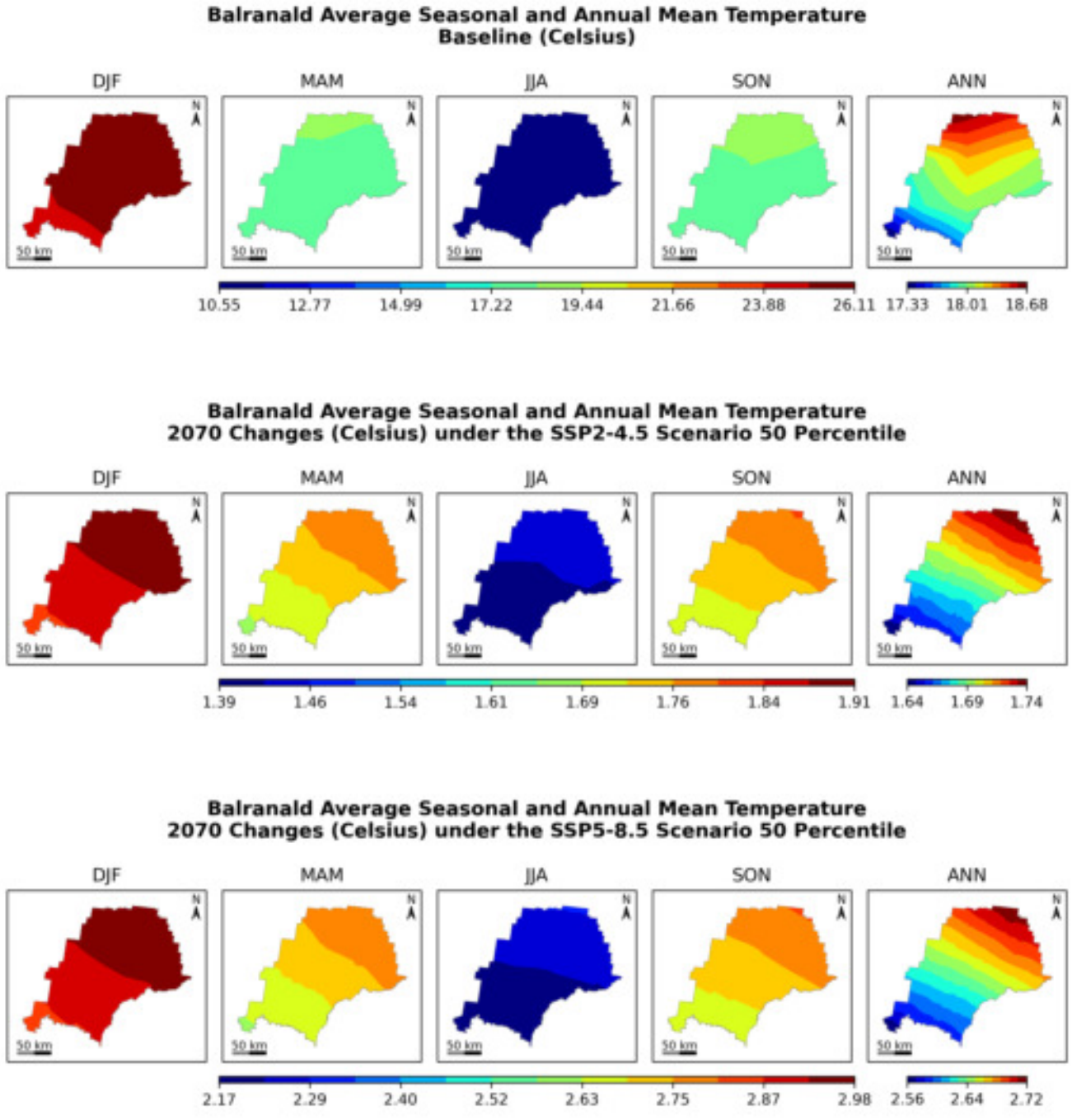


Figure 3: Balranald, Average Seasonal and Annual Precipitation Baseline (mm) and Changes (%).

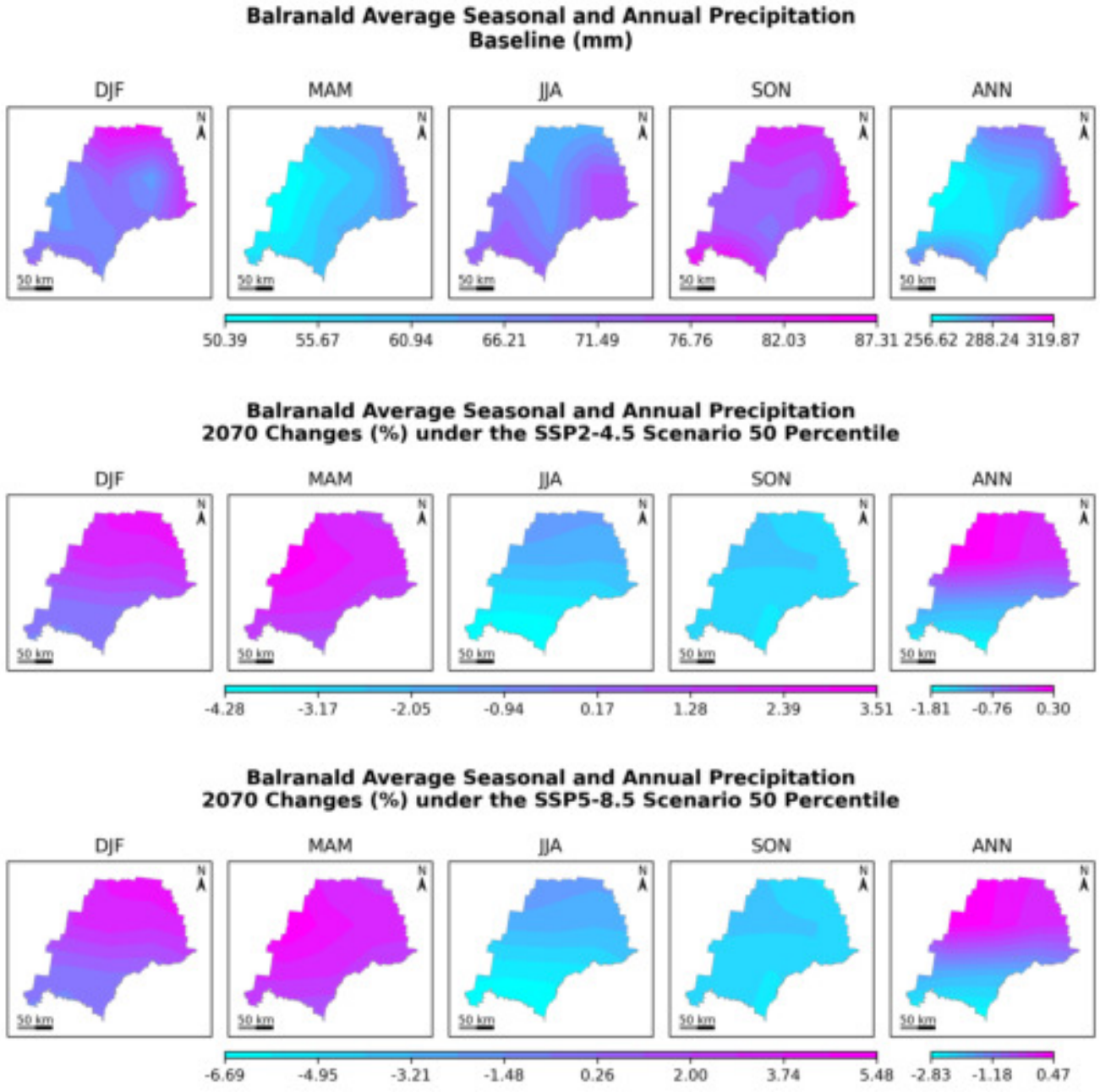


Table 7. SimCLIM Projections for Balranald using SSP2-4.5 (left column) and SSP5-8.5 (right column)

Average Seasonal and Annual Mean Temperature Baseline (Celsius) and Changes (Celsius) - 50th Percentile (Brackets 5th and 95th Percentile)

Baseline	18.11	18.11
2050	1.24 (0.85, 1.69)	1.62 (1.11, 2.20)
2070	1.70 (1.16, 2.31)	2.65 (1.82, 3.60)
2090	1.91 (1.31, 2.59)	3.82 (2.61, 5.18)

Average Seasonal and Annual Maximum Temperature Baseline (Celsius) and Changes (Celsius) - 50th Percentile (Brackets 5th and 95th Percentile).

Baseline	25.48	25.48
2050	1.32 (0.86, 2.00)	1.73 (1.13, 2.61)
2070	1.81 (1.18, 2.73)	2.83 (1.85, 4.27)
2090	2.03 (1.33, 3.07)	4.06 (2.66, 6.14)

Average Seasonal and Annual Minimum Temperature Baseline (Celsius) and Changes (Celsius) - 50th Percentile (Brackets 5th and 95th Percentile).

Baseline	10.65	10.65
2050	1.21 (0.84, 1.64)	1.58 (1.10, 2.15)
2070	1.65 (1.16, 2.25)	2.58 (1.81, 3.51)
2090	1.86 (1.30, 2.53)	3.72 (2.60, 5.05)

Average Seasonal and Annual Precipitation Baseline (mm) and Changes (%) - 50th Percentile (Brackets 5th and 95th Percentile).

Baseline	275.32	275.32
2050	-0.36 (-21.48, 29.07)	-0.48 (-28.09, 38.01)
2070	-0.50 (-29.41, 39.80)	-0.78 (-45.93, 62.16)
2090	-0.56 (-33.04, 44.72)	-1.12 (-66.09, 89.44)

Property scale

An assessment was undertaken at the property scale to demonstrate the vulnerability private domestic water supplies on rural and remote properties to changing climatic conditions. Rainwater harvesting scenarios were undertaken using a spatial risk-based assessment model for climate adaptation using the SimCLIM modelling system (Warrick et al 2012). This demonstration exposed several difficulties in trying to generate projections for sites in desert environments.

Calculations of rainwater harvesting confirmed that this source of domestic supplies is unreliable, and that demand should be carefully managed to ensure that there is adequate potable water to meet household needs (See **Annex 3-G** in **Volume 3)**. Reliance on rainwater as a primary source needs to be critically evaluated at the individual property scale. Differences in roof areas being harvested, quantity of water held in storage tanks, numbers of people in the household and the amount of water that they consume each day make it difficult to assess adequacy of supply.

Additionally, in hot dry climates a considerable amount of dust and general debris accumulates on the roof. Infrequent and low rainfall events means that first flushes must be managed, and contaminated water diverted from the tank. In the context of sporadic rainfall events, the diverted volume could be considerable, and the yield reduced. The number of low rainfall events that do not lead to flushing of a roof may increase. With climate change, this and the core issues of yield versus demand will not be fundamentally changed at the household scale, and there will be a serious deficit in supply of potable water.

Harvesting greater areas of roof and providing more tanks will not increase resilience. For Balranald Shire, increasing resilience to changing climatic conditions requires more innovative approaches to using shallow and deep underground supplies, coupled with utilising the limited rainwater supplies for drinking and cooking. And in some cases, this requires changes in attitude and behaviour towards the risks to adequate and safe domestic water supplies from changed climates and the ways in which householders can address threats to their livelihoods, lifestyles and health. Further communication to those dependent on rainwater harvesting should address both the threats and possible options to ensure the adequacy and safety of their domestic water supplies.

Demographic implications of climate change

Sinclair Knight Merz (2010) pointed out that scientific projections broadly identify and quantify a diverse range of potential future impacts of climate change on all levels of community, business, and governmental activities. These impacts include:

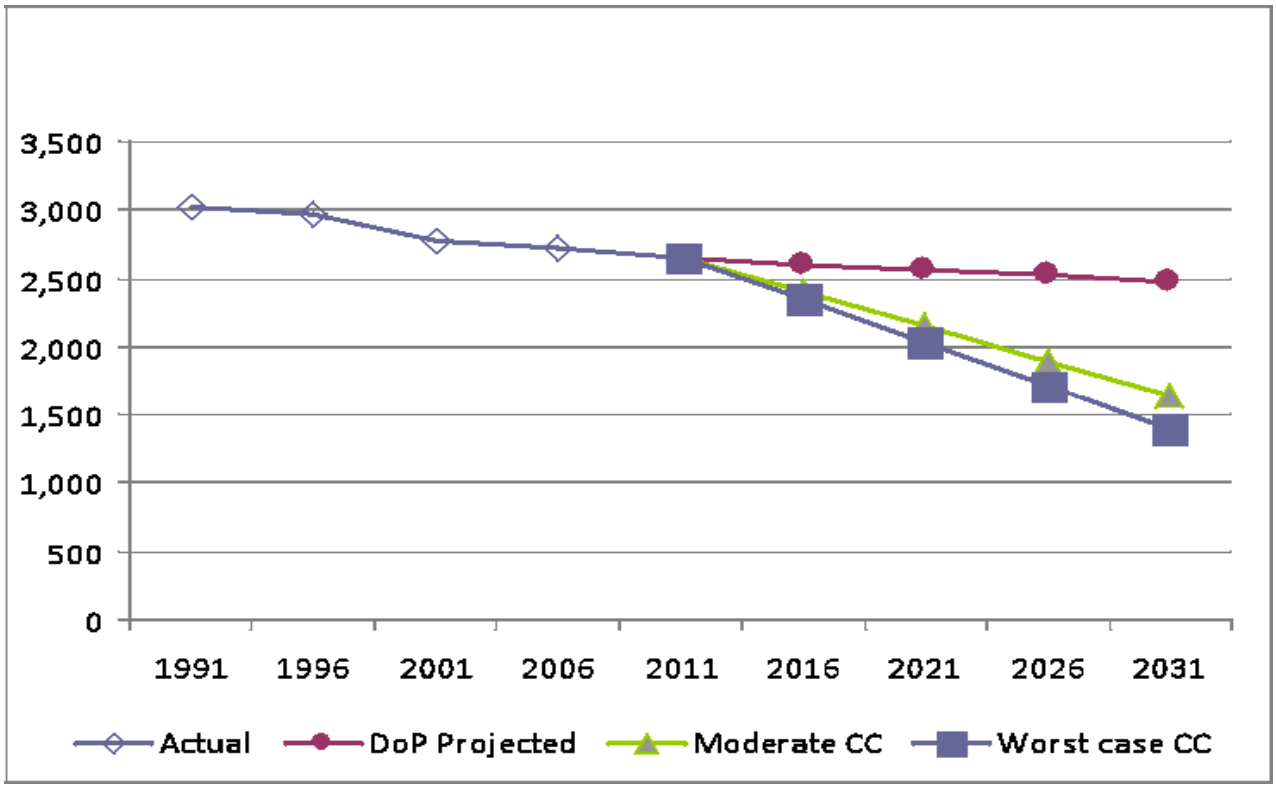
- less rainfall and water for extractive purposes for primary industry and human consumption
- higher rates of evaporation of surface water resources

- lower levels of soil moisture
- higher temperatures and greater health risks
- increased incidence of extreme weather events (prolonged droughts, floods, and bushfires)

Additionally, Sinclair Knight Merz (2010) noted that although Balranald Shire's rural industry will be adversely impacted by changed climates it has the capacity to adapt. They conclude that this could be achieved by accelerated business consolidation and efficiency gains to the benefit of the stronger businesses. As well, Sinclair Knight Merz (2010) argued that the population of Balranald Shire is expected to be adversely affected by climate driven changes to agricultural practices with the move to fewer and larger agribusinesses, larger and more efficient equipment and the use of contractors resulting in fewer employees.

The 2010 report of the Strengthening Basin Communities Project for the Western Cluster highlighted the past and projected population for Balranald Shire from 2001 to 2031. These are depicted schematically in **Graph 1.** Based on this prognosis, Sinclair Knight Merz (2010) made 'A Call to Action' to maintain the then current population of 2 470 people. They said that the following must occur to counter the projected population loss.

Graph 1: Balranald Shire Population Projections 2010



Source: Sinclair Knight Merz (2010) Strengthening Basin Communities, Community Development Plans for Balranald and Euston 2012-16

- Climate change base case – retain and/or attract 18 people per year for the next 30 years
- Moderate climate change case – retain and/or attract 28 people per year for the next 30 years
- Worst case scenario for projected climate change – retain and/or attract 36 people per year for the next 30 years

Sinclair Knight Merz (2010) concluded that 'without a community based and mutually agreed set of strategic directions and a plausible set of action plans, Balranald Shire is faced with inevitable population decline, with or without climate change'. The ability to "turn the tide" will be driven by the promptness and level of acceptance of the facts that changed climates could have severe demographic consequences.

Health dimensions of changing climates

The health implications of changing climatic conditions are broadly dimensioned at **Attachment 3** of **Volume 1**. As stated in the aim: *This project will establish a baseline assessment of risk to human health-.* Pursuant to the revised Action Plan of 08/05/2021 (see **Volume 3, Annex 3-A**) the health tasks were to:

- Advise and assist Council with: *Engaging with relevant health professionals to document current and potential levels of health issues and risks relating to poor quality water supplies.*
- Report on numbers presenting to medical services with physical and psychological symptoms attributable to poor quality water and adequacy of supply (Goal *kpi – 50 percent reduction from baseline numbers)*.

The first task was underpinned by NSW Health documents that are accessible on-line (see **Table 8**). The second task entailed re-establishing links with NSW Health to get an update on the policy settings and their position on the population/public health dimensions of the effects of changing climatic conditions with respect to: communities and individuals in Far West NSW; demand for medical and related health services; and the adequacy and quality of rural water supplies. NSW Health were unable to participate in the IRCC project because of their additional workloads created by the COVID pandemic.

Table 8. Key NSW Health documents

Document	Web URL
Private water supply guidelines	http://www.health.nsw.gov.au/environment/water/Publications/private-water-supply-guidelines.pdf
Rainwater tank information	http://www.health.nsw.gov.au/environment/water/Documents/rainwater_tanks.pdf
NSW Health *Naegleria fowleri* Fact Sheet	https://www.health.nsw.gov.au/Infectious/factsheets/Pages/Naegleria-fowleri.aspx

Attachment 3 of **Volume 1** was prepared by Dr Teresa Lewis. And it dimensions key health implications of changing climates through poor quality water, and heat stress.

Initially, it was hoped that direct co-benefits from the BSC IRCC demonstration project could be demonstrated by measurable reduction in costs of hospital and medical services needed to address physical and mental health issues arising from inadequate supplies and poor-quality water. As shown in **Table 9,** because of the current health data coding and regional arrangements, it is not possible to demonstrate that projects such as the SSDW initiative could reduce demand for medical services and costs.

Table 9. Focusing questions to help dimension health risks from poor quality water and heat waves

Question	Finding	Comments
• Are the effects of *disease-causing microorganisms such as Giardia, Cryptosporidium, Salmonella, Shigella, Campylobacter, some strains of Escherichia coli (E. coli), cyanobacteria (blue green algae), Rotavirus, Norovirus, and Hepatitis A virus,* as well as many others relating to poor water quality reported to and by NSW Health?	They are not coded and reported hence there is no data	Health data is collated regionally. Water related illnesses have not been reported and recorded in NSW for some decades. Heat related illness is not coded and reported.
• How many cases of poor water quality and heat stress illnesses are reported/known/suspected in the Far West region of NSW in general and Balranald Shire in particular?	Unknown because they are not coded and recorded	These data re essential if the health risks and impacts from changing climates are to be dimensioned
• Are water and heat related health issues more prevalent in the Aboriginal population than non-Aboriginal communities?	Unknown	An important omission considering known kidney diseases in First Nation communities
• Are there are identifiable age-related patterns in health effects eg. Babies, young children and the frail aged?	No data, unable to be answered,	An important omission considering known age-based vulnerabilities

5. OBSERVATIONS AND CONCLUDING REMARKS

Existing conditions

Aboriginal occupation of the area covered by the Shire extends back at beyond 50,000 years. As indicated in the Preface, the World and National heritage values of the Willandra Lakes Region show that environmental and social baselines for Balranald Shire can be benchmarked by over 40 000 years of utilisation of the land and the water resources of country by First Nations people. As said in Section 3, at the height of the last 'Ice Age' the area abounded with a diverse assemblage of terrestrial and aquatic fauna. Today it is a parched semi desert landscape that supports dry land and irrigated primary production as well as national and international tourism and recreation. Albeit with a declining population and fewer households on rural properties.

For this baseline report, biophysical conditions across the Shire are overviewed in terms of climate parameters (temperature and rainfall), topography and regionalization, vegetative cover and protected areas, and water resources and their management. Maps are provided to illustrate: the regional climate classes that characterise the geographic setting; the topographic pattern reflecting the major basin structures, and the vegetation assemblages and parks. Water resources are mapped by way of the rivers and drainage systems, and the infrastructure on properties (dams, bores, tanks). Data is presented showing the sources of domestic supplies, quantities being consumed, types of storage and treatment being used on properties. Bacteria could be present in over 50% of storage tanks.

Together, the climate, topography, drainage patterns and vegetative cover are indicators of a land surface that is vulnerable to environmental and population health hazards and risks arising from increasing temperatures and variable rainfall under climate change. Within this biophysical context, post-European settlement socio-economic conditions are contextualised by a history of changing agriculture land uses and the accompanying population decline. However, diversification of the local economy, through irrigated primary industry, solar energy enterprises, mineral sands extraction and eco and Aboriginal cultural heritage-based tourism, is starting to halt the decline and attract more people to the Shire.

Implications of changing environmental conditions

Based on AdaptNSW Far-West climate change projections by 2080 increases in mean maximum temperature across the Shire could range from 0.5-1.5^{0}C (current mean 24.4^{o}C) and mean minimum temperatures by 0.5-2.0^{o}C (current mean 10.2^{o}C). The number of days with temperatures exceeding 35^{o}C could rise from the present 64 to 94 per annum.

Based on SimCLIM projections, over the same time-period precipitation (from south to north across the Shire) could continue to decline. And the pattern of rainfall events could continue to be highly variable across the regional production and conservation landscapes due topographic and micro-climatic influences such as the basin structure of the drainage system, levels of desertification, and patterns of clearing and remnant vegetation cover.

This situation indicates that the projected impacts from changing climatic conditions reported by Sinclair Knight Merz (2010) are realistic and could affect community, business, and governmental activities. Specifically. there will be:

- less rainfall and water for extractive purposes for primary industry and human consumption and higher rates of evaporation of surface water resources
- lower levels of soil moisture
- higher temperatures and greater health risks
- increased incidence of extreme weather events (prolonged droughts, floods, and bushfires)

Reduction in the availability, adequacy, and quality of water supplies from dams, bores and rainwater harvesting on private properties because of higher temperatures, lower rainfall, increased evaporation, and prolonged drought could constrain economic activities and adversely affect livelihoods and lifestyles in the Shire. Without property scale adaptive measures, such as increased use of shallow and deep bores, there will be inadequate non-scheme water for household use. And this rainwater will need to be carefully conserved at the property scale through demand management and simple water treatment processes to reduce health risks from poor quality supplies due to the hotter and dryer conditions.

Meeting the purposes of the Baselines Report

The purposes of the Environmental and Social Baselines are listed on page 3, and they are key to the delivery of the BSC IRCC project. To quote from the 2019 BSC proposal to NSW Department of Planning, Industry and Environment (DPIE) and Local Government NSW for project funding: *This project aims to identify and pilot measures to mitigate the risk of increasing temperatures and variable rainfall under climate change to the provision of adequate and safe private domestic water supplies for people on rural and remote properties in Balranald Shire.* Towards the attainment of this aim, Objective 2 of the project was: *To establish an 'environmental baseline' for domestic supplies on rural and remote properties.*

Pursuant to Australian legislation, the term environment is all encompassing and includes physical, biological, social, economic, cultural and heritage elements of the surroundings and activities of people. In this context, Objective 2 has been achieved by collating descriptive and mapped information on biophysical, socio-economic and climate change conditions and implications for Balranald Shire in its regional setting.

The 'environmental baseline' for domestic supplies on rural and remote properties in Balranald Shire is characterized by regional landscapes that biophysically reflect the effects of cyclic drying since the last ice age. Post European settlement, this trend has been exacerbated by periods of prolonged drought on land surfaces and drainage patterns modified for agriculture and pastoral use. In this setting, resilience and adaptions to climate change are benchmarked by the utilisation of this country by First Nations people. And there are learnings to be had from linking cultural and safe water values to ensure scarce supplies are adequate and not a health risk.

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ANNEX A

SPATIAL DATASETS METADATA

Maps 2 and 4-15 were created by Deanna Duffy of the Spatial Data Analysis Network (SPAN) at Charles Sturt University, July 2021.

Software: Esri Inc. (2021). *ArcGIS Pro* (Version 2.8). Esri Inc. https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

Spatial Dataset	Digital boundaries
Data Type:	Polygon shapefiles
Data Description:	State and local government area boundaries
Spatial Reference:	Geocentric Datum of Australia (GDA94)
Data Source:	ABS, Census 2016
Currency:	2016

Link to data: https://www.abs.gov.au/websitedbs/D3310114.nsf/home/Digital+Boundaries

Spatial Dataset	Shuttle Radar Topography Mission V2
Data Type:	Grid
Data Description:	25 m elevation
Spatial Reference:	*World Geodetic System 1984* (*WGS84*)
Data Source:	Geoscience Australia
Currency:	2010

Link to data: http://www.ga.gov.au/scientific-topics/national-location-information/digital-elevation-data

Spatial Dataset	Catchment Scale Land Use of Australia
Data Type:	Polygon shapefile
Data Description:	Land use
Spatial Reference:	GDA94 / Australian Albers
Data Source:	Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
Currency:	Update 2020

Link to data: https://www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-of-australia-update-december-2018

Spatial Dataset	NSW Woody Extent and Foliage Projective Cover
Data Type:	Grid
Data Description:	5 m woody vegetation cover
Spatial Reference:	Geocentric Datum of Australia (GDA94)
Data Source:	Department of Planning, Industry and Environment
Currency:	2015

Link to data: https://datasets.seed.nsw.gov.au/dataset/ba29339a-22d3-474b-ab27-c08e966ddda2/metaexport/html

Spatial Dataset	Geofabric Surface Cartography V3.2
Data Type:	File geodatabase feature classes (line, point and polygons)
Data Description:	Waterlines, waterbodies, floodplains and dams
Spatial Reference:	Geocentric Datum of Australia (GDA94)
Data Source:	*Bureau of Meteorology*
Currency:	2017

Link to data: http://www.bom.gov.au/water/geofabric/download.shtml

Spatial Dataset NSW Digital Cadastral Data Base (DCDB
Data Type: Shapefiles (Line, point, polygon)
Data Description: Property boundaries
Spatial Reference: Geocentric Datum of Australia (GDA94)
Data Source: NSW Spatial services
Currency: 2021
Link to data: https://maps.six.nsw.gov.au/clipnship.html

Spatial Dataset NSW DIGITAL TOPOGRAPHIC DATABASE PACKAGE DTDB
Data Type: Shapefiles (Line, point, polygon)
Data Description: Places, water, roads, tanks, POIs (bores)
Spatial Reference: Geocentric Datum of Australia (GDA94)
Data Source: NSW Spatial services
Currency: 2021
Link to data: https://maps.six.nsw.gov.au/clipnship.html

Spatial Dataset Vegetation Formations and Classes of NSW (version 3.03)
Data Type: Shapefiles (Line, point, polygon)
Data Description: property
Spatial Reference: GDA94 / NSW Lamberts
Data Source: Department of Planning, Industry and Environment
Currency: Updated 2017
Link to data: https://datasets.seed.nsw.gov.au/dataset/vegetation-classes-of-nsw-version-3-03-200m-raster-david-a-keith-and-christopher-c-simpc0917

Spatial Dataset Balranald Airport
Data Type: Point shapefile
Data Description: Balranald Airport
Spatial Reference: Geocentric Datum of Australia (GDA94)
Data Source: Created by SPAN using ESRI's Street Basemap
Currency: 2021
Link to data: https://datasets.seed.nsw.gov.au/dataset/vegetation-classes-of-nsw-version-3-03-200m-raster-david-a-keith-and-christopher-c-simpc0917

Spatial Dataset Murray-Darling Basin Aquatic Assets
Data Type: File geodatabase
Data Description: Weirs
Spatial Reference: Geocentric Datum of Australia (GDA94)
Data Source: Australian Rivers Institute, Griffith University and CSIRO
Currency: 2012
Link to data: Murray–Darling Basin Authority

Spatial Dataset: Climate Projections for your Region
Data Type: PDF, converted to png and georeferenced in ARCGIS Pro 2.8.0
Data Description: Far West Climate Change Downloads
Spatial Reference: N/A
Data Source: *Bureau of Meteorology*
Currency: 2021
Link to data: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region