NON-PRESCRIBED SURFACE WATER RESOURCES ASSESSMENT

NORTHERN AND YORKE NATURAL RESOURCES MANAGEMENT REGION

2013

Government of South Australia
Department of Environment, Water and Natural Resources

NON-PRESCRIBED SURFACE WATER RESOURCES ASSESSMENT NORTHERN AND YORKE NATURAL RESOURCES MANAGEMENT REGION

DEPARTMENT OF ENVIRONMENT, WATER AND NATURAL RESOURCES

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DEWNR TECHNICAL REPORT 2013/03

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Foreword

The Department of Environment, Water and Natural Resources (DEWNR) is responsible for the management of the State's natural resources, ranging from policy leadership to on-ground delivery in consultation with government, industry and communities.

High-quality science and effective monitoring provides the foundation for the successful management of our environment and natural resources. This is achieved through undertaking appropriate research, investigations, assessments, monitoring and evaluation.

DEWNR's strong partnerships with educational and research institutions, industries, government agencies, Natural Resources Management Boards and the community ensures that there is continual capacity building across the sector and that the best skills and expertise are used to inform decision making.

Allan Holmes
CHIEF EXECUTIVE
DEPARTMENT OF ENVIRONMENT, WATER AND NATURAL RESOURCES

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1. Introduction

In an environment where water resources are increasingly scarce, a better understanding of water resource capacity and a more proactive approach to management is required. The Government of South Australia (2009) in its *Water for Good* plan acknowledged the importance of baseline understanding of South Australia's (the State's) resources. Status and condition of resources and their regular assessment is important to enhance sustainable development opportunities, to avoid overuse and to act proactively to any significant quantitative changes in these resources. *Water for Good* supports this through an action to expand monitoring networks and increase the regularity of assessments for status and condition reporting of resources. The Department of Environment, Water and Natural Resources (DEWNR) has the lead-agency responsibility for ensuring the sustainable management of groundwater and surface water resources of the State. As such, DEWNR has developed a program to fulfil responsibilities under the *Natural Resources Management Act 2004* and in response to water security issues facing the State. This report presents findings of the sub program *Non-prescribed surface water resources assessment – Northern and Yorke Natural Resources Management Region*.

Water resource management is important for sustaining water-related activities like pastoral, environmental and community use. The pressure to access new water resources will also increase. The impacts of land-use change such as mining and energy operations may go undetected, unless suitable monitoring and assessment is in place (Government of South Australia 2009). New pressures are likely to be realised for water resources that traditionally have not been utilised or managed. Baseline information is important to allow appropriate planning to avoid unsustainable extraction and detrimental resource decline.

There is only limited understanding of surface water resources in most non-prescribed regions across the State. Current knowledge gaps regarding the quantity and quality of surface water resources present significant barriers to the management and potential future development of surface water systems. Addressing these gaps is especially important due to anticipated increases in demand for water, changes in land use and potential impacts associated with a changing climate.

This report aims to provide an overview of surface water information, where available, for the Northern and Yorke Natural Resources Management Region (region). This includes collating and presenting existing data and information about the non-prescribed surface water resources of the region. The region is one of eight Natural Resources Management (NRM) regions of the State (Figure 1) established under the *NRM Act 2004*. The Clare Prescribed Water Resources Area (PWRA) and the Baroota PWRA are within this region. It is recommended this report be read in conjunction with reports available on groundwater and environmental water requirements of the region, to gain a broader understanding of the water resources in the region.

1.1. Objective

The objective of this report is to improve the understanding of non-prescribed surface water resources in the region. Water resources are important for sustaining agriculture, industry, mining and rural townships, but non-prescribed regions have traditionally been poorly understood due to limited monitoring and investigation programs. A better understanding of water resources can assist with development of plans and policies for sustainable resource development in the region.

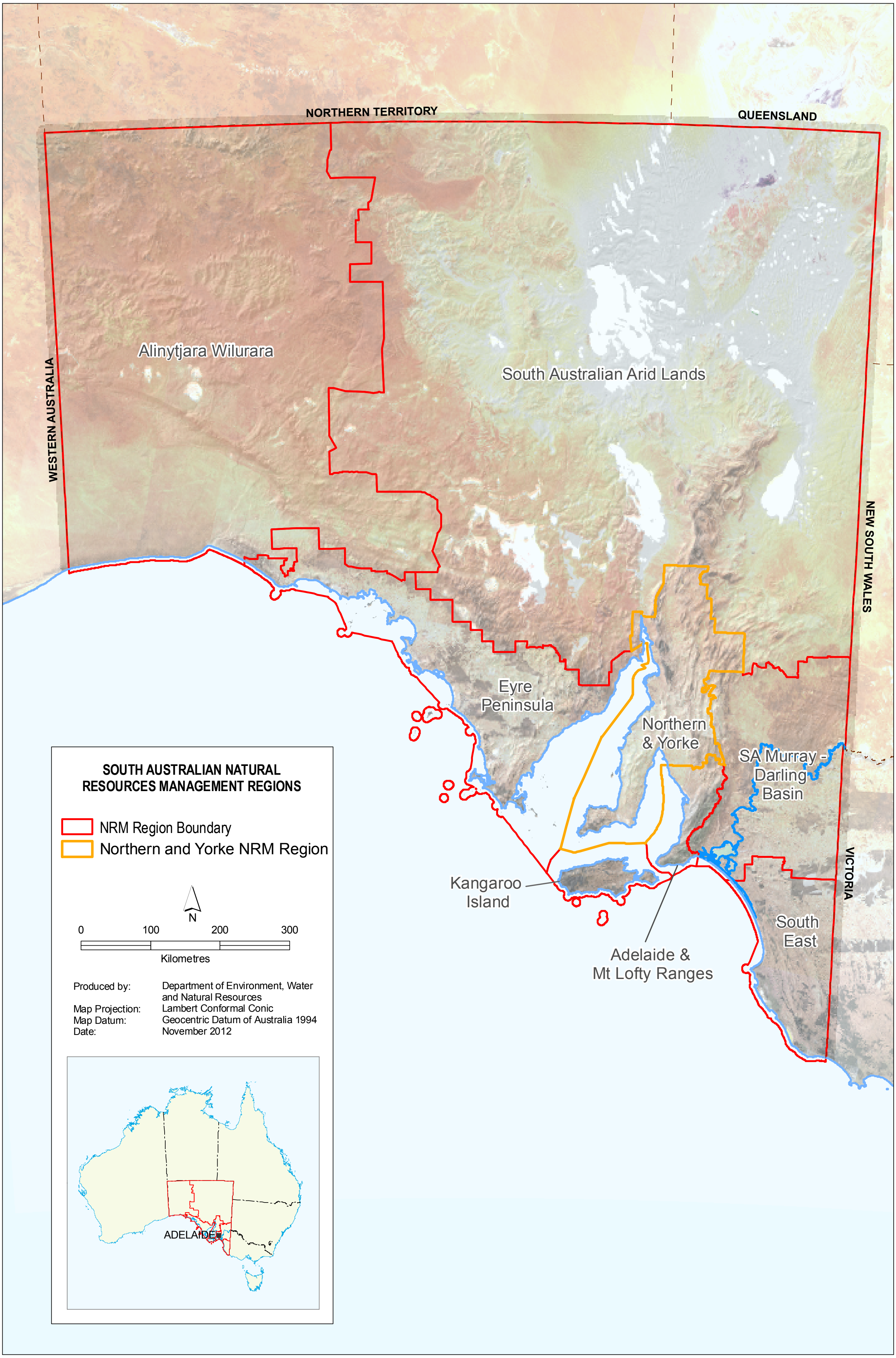

Figure 1. Location of the Northern and Yorke NRM Region

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1.2. Earlier studies

Numerous studies have previously been undertaken for the region on topics such as climate change, monitoring reviews, ecological assessments and water management plans. Some of the recent surface water reports for the region are summarised below.

River management plans have been developed for the Wakefield River (EPA 2000), the Broughton River (DWLBC 2004) and the Light River catchments (DWLBC 2004). The plans were prepared as part of the Mid North Rivers Management Planning Project in 2000, due to concerns from landholders on the condition of watercourses, water quality, streamflow and a lack of an integrated catchment wide approach to water resource management. The plans will be used as a decision making tool for landholders and key stakeholders who have an interest in river management.

The Integrated NRM Plan for the Northern and Yorke Agricultural District (NYAD INRMC 2003) was developed to be a core reference document for NRM planning and to be used for development of funding programs in the region. The plan adds to previous work by community groups, soil conservation boards, local government and state agencies in an attempt to improve the condition of natural resources in the region.

Salinity management plans have been developed for the Upper Light River (Harding *et al.* 2003), South East Broughton River (Harding *et al.* 2005) and Northern Broughton River (Harding *et al.* 2006). The plans describe the hydrogeological background of the catchments, identify the extent and risk of salinity in the catchments, review the options for managing salinity and develop an action plan to guide the local community.

The Natural Resources Management Act (2004) requires NRM Boards to prepare a Water Allocation Plan (the Plan) for each prescribed water resource in its region. A Water Allocation Plan (WAP) for the Clare Valley PWRA (NYNRMB 2009), which is within the region, was prepared to “provide criteria by which decisions about the regulation and use of water are made, that ensure that water resources are managed sustainably for current and future users and water dependent ecosystems, including downstream users and downstream water dependent ecosystems”. The Plan provides a set of principles to be used for the allocation, use and transfer of water in the Clare Valley PWRA.

The Northern and Yorke Regional NRM Plan (NYNRMB 2009a) is a comprehensive document describing the climate, soil, water, water environments and biodiversity assets in the region, as well as the influence of people and pest plants/animals. The report focuses on delivering ecologically sustainable development in the region, with an approach based on intergenerational equity and the precautionary principle, to ensure there is a long term balance between the use, conservation and development of the region’s natural resources.

SA Water’s Long Term Plan for Yorke Peninsula report (SA Water 2010) considered current and future potable water demand and supply, the condition of water resources from where potable water is sourced and options to ensure future demands could be met.

The Northern and Yorke Demand and Supply Statement (DFW 2011) is one of eight regional demand and supply statements produced by DEWNR (formerly Department for Water). The statements were designed to project water-supply availability and demands for a region and project any demand-supply imbalance in the future. Each statement will be reviewed at regular intervals, checking the assumptions in the statement against the status of the resource. The Northern and Yorke Demand and Supply Statement included an overview of current resources in the region, future demand and supply projections and findings based on demand-supply projections, population growth, climate change, water quality, land use changes and isolated demand-supply issues.

The Impacts of Climate Change on Water Resources report (Green *et al.* 2011) involved detailed hydrologic modelling to assess the impact of climate change scenarios on prescribed surface water and groundwater resources in the region, namely the Clare

PWRA and the Baroota PWRA. Models were developed to produce outputs based on 2030, 2050 and 2070 time horizons and high and low greenhouse gas emission scenarios.

Other investigations undertaken for the region include:

- Willochra Catchment Hydrological and Ecological Assessment (Risby *et al.* 2003)
- Ecological Condition Assessment: Streams of the Mambray Coast (Deane *et al.* 2005)
- Rocky River Catchment Water Resources Assessment (Deane 2005a)
- Reviews of monitoring in the region include the Northern and Yorke NRM Region Water Monitoring Review (Roberts 2007)
- Preliminary Estimates of Farm Dam Development in the Northern and Yorke NRM Region (Deane and Graves 2008)
- Current Monitoring Activities Northern and Yorke NRM Board Area (Australian Groundwater Technologies 2010).

2. Characterising the region's surface water hydrology

2.1. Climate

The Northern and Yorke climate is characterised by mild winters and hot summers, but this is subject to variability across the region (Northern and Yorke Natural Resources Management Board 2009a). Coastal areas generally experience a milder and wetter climate, while rainfall decreases and conditions tend toward extremes in temperature with increasing distance inland. According to the Köppen-Geiger climate classification system (Peel *et al.* 2007), regional-scale climate can be divided into two broad categories divided by a line between Wallaroo and Clare (Figure 2). South of this line, the climate can be described as temperate with distinctly dry and warm summers. To the north, the climate can be described as semi-arid to arid with hot dry summers and cold winters.

The Bureau of Meteorology (BoM) website (2012) provides temperature statistics for the region. Warooka is located in the region's south at the base of Yorke Peninsula and has a mean summer (December to February) maximum temperature of 26.5°C and a mean monthly minimum temperature during the winter months (June to August) of 7.9°C. Clare is located in the central part of the region and more elevated compared to Warooka. Clare has a mean summer maximum temperature of 29.0°C and a mean monthly minimum temperature during the winter months of 4.4°C. Hawker is located in the northern-most part of the region and has a mean summer maximum temperature of 33.1°C and a mean monthly minimum temperature during the winter months of 4.2°C. Maximum temperatures have risen faster in the State compared to other States of Australia, but a slower rise has been observed with minimum temperatures (Suppiah *et al.* 2006).

Based on BoM rainfall data from 1900-2010, higher rainfall is recorded in the central part of the region between Clare to Port Augusta and also the lower half of Yorke Peninsula, generally between 400-800 mm. The northern part of the region is drier, averaging less than 300 mm. The spatial distribution of rainfall over the region is shown in Figure 3 for:

1. long term average annual rainfall for the period 1900-2010
2. short term average annual rainfall for the period 2001-10.

The average annual rainfall for the period 2001-10 shows a drier period compared to the long term average. The north of the region experienced wider-spread low rainfall from 2001-10, as did Yorke Peninsula. The central part of the region, while still experiencing the highest rainfall in the region, was lower than the long term average rainfall for this period.

Climate change projections indicate a reduction in rainfall and an increase in temperature for the region (Suppiah *et al.* 2006). Based on climate change projections for the Clare Valley PWRA and the Baroota PWRA, the region is expected to experience reduced runoff due to reduction in rainfall (Green, Gibbs & Wood 2011). Reductions in runoff would vary across the region, with the Baroota Reservoir catchment being less sensitive to changes in rainfall than the Clare Valley catchments.

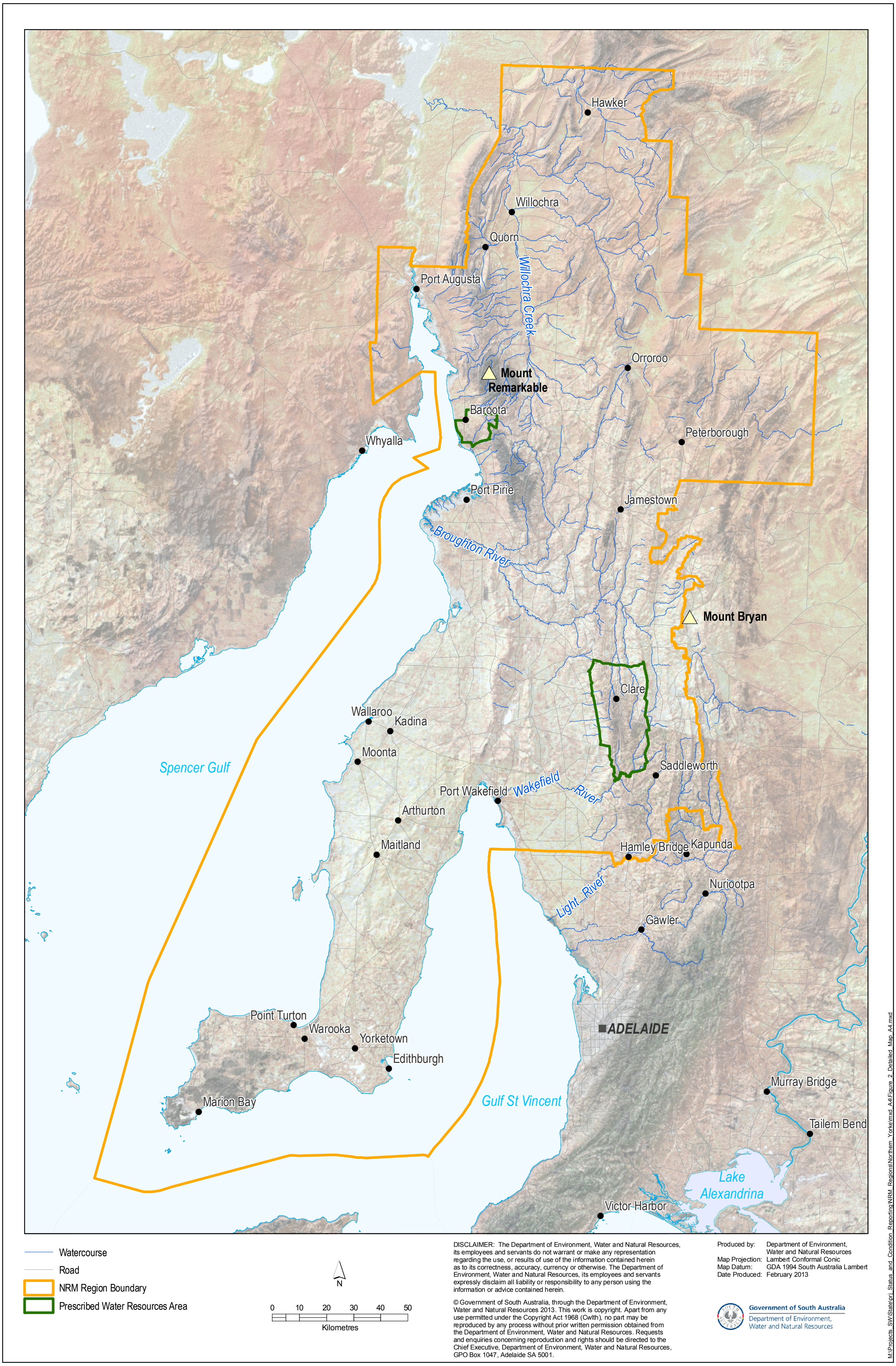


Figure 2. Detailed map of the Northern and Yorke NRM Region

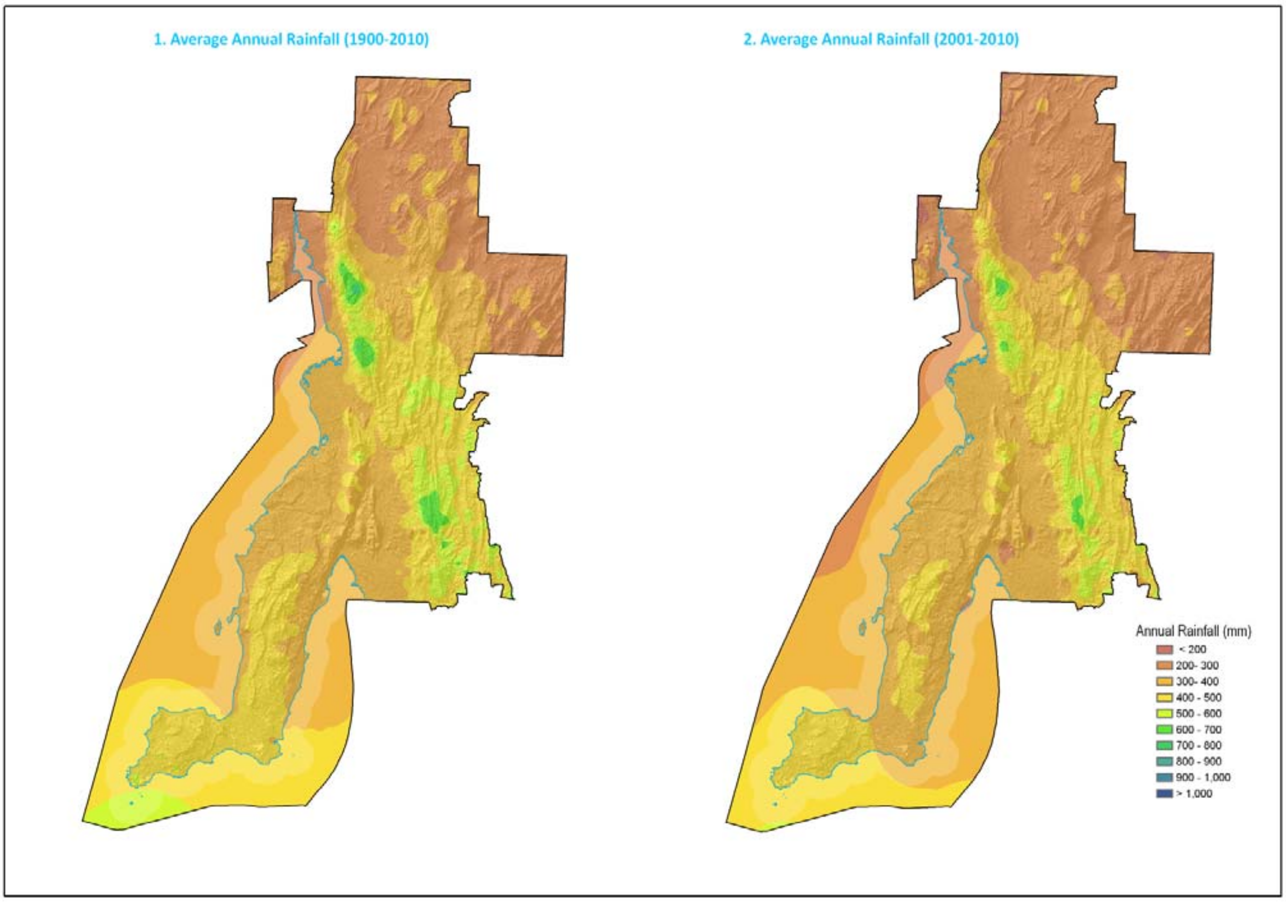


Figure 3. Annual rainfall distributions over the Northern and Yorke NRM Region

Average annual evaporation rates increase from south to north across the region with the lower Yorke Peninsula experiencing 1400 mm, compared to 2600 mm in the north of the region (BoM 2012). Daily evaporation data are recorded at three active rainfall monitoring stations located at Bundaleer Reservoir (M021009), Beetaloo Reservoir (M021124) and Price (M022015) (Figure 10). Evaporation records at Bundaleer commenced in 1968, Beetaloo in 1981, while Price is more recent, commencing in 2005. Annual evaporation recorded at Bundaleer and Beetaloo Reservoir provides a longer record of conditions compared to Price, which has only seven years of available data.

Table 1. Evaporation data for the Northern and Yorke NRM Region

Evaporation Station	**Station No.**	**Period of Record**	**Average Annual Evap. (mm)**
Spalding (Bundaleer Reservoir)	M021009	1968-2011	1870
Laura (Beetaloo Reservoir)	M021124	1981-2011	1718
Price	M022015	2005-11	1934

2.2. Topography

The topography across Yorke Peninsula is undulating and gently rolling, with elevations generally less than 100 m Australian Height Datum (AHD). Arthurton, located around central Yorke Peninsula (Figure 2), reaches an elevation of approximately 250 m AHD. To the east of Gulf St Vincent, the northern Mount Lofty Ranges extend from Kapunda in the south to beyond Peterborough in the north-east. In contrast to Yorke Peninsula, relief across the ranges is commonly around 300 m AHD and reaches a maximum of around 940 m AHD at Mount Bryan. The Southern Flinders Ranges is located to the east and north-east of Port Pirie. Relief in this region varies from low lying coastal plains around Baroota, through to gorges and ranges which show contrasting elevations of between 300–800 m AHD.

2.3. Drainage divisions, river basins and catchments

Twelve drainage divisions and 246 river basins were defined by the Australian Water Resources Council in the early 1960s. Drainage divisions were defined both by major topographic features of Australia, and major climatic zones to give broadly homogeneous hydrologic regions. The region is part of the South Australian Gulf, Lake Eyre and Murray-Darling drainage divisions (Figure 4).

River basins were defined by major watershed boundaries. There are nine river basins which lie in part within the NRM region boundary. These include the Broughton River, the Wakefield River, the Willochra Creek, the Mambray Coast and parts of the Gawler River, the Lake Frome, the Lake Torrens, the Lower Murray River and the Spencer Gulf basins.

A brief description of each river basin is provided below. A description of the key hydrological features for each of the main river systems then follows.

The Broughton River basin is the largest within the boundary of the NRM region with an area of approximately 16 300 km^2. The majority of watercourses in this basin are located in the northern portion with some water bodies present at the base of Yorke Peninsula in the south. Major watercourses of the Broughton River basin include Hill River, Hutt River, Rocky River and the Broughton River.

The extent of the Willochra Creek basin is also largely located within the boundary of the NRM region in the regions north. Willochra Creek is the major watercourse of the basin and contributes streamflow to Lake Torrens. The area of the basin is approximately 6600 km^2. Much of the basin is located within the higher elevation areas of the Flinders Ranges.

The Wakefield River basin is largely located within the boundary of the NRM region with the Wakefield River being the major watercourse of the basin. The Wakefield River basin has a total area of approximately 1900 km^2, and is one of the smaller basins in the region. Higher elevations are on the eastern side of the basin, with watercourses flowing to the west and ultimately discharging to Gulf St Vincent.

Located in the north-west of the region, approximately half of the Mambray Coast's 5900 km^2 is within the NRM region boundary. Watercourses flow down the eastern side of the basin along the western edge of the Flinders Ranges, and discharge to the upper areas of Spencer Gulf.

The northern portion of the Gawler River basin is within the boundary of the NRM region. The total area of the basin is approximately 4550 km^2. Major watercourses of the Gawler River basin include the Gawler River and the Light River, which both discharge to Gulf St Vincent. Headwaters of the Light River are located within the boundary of the NRM region.

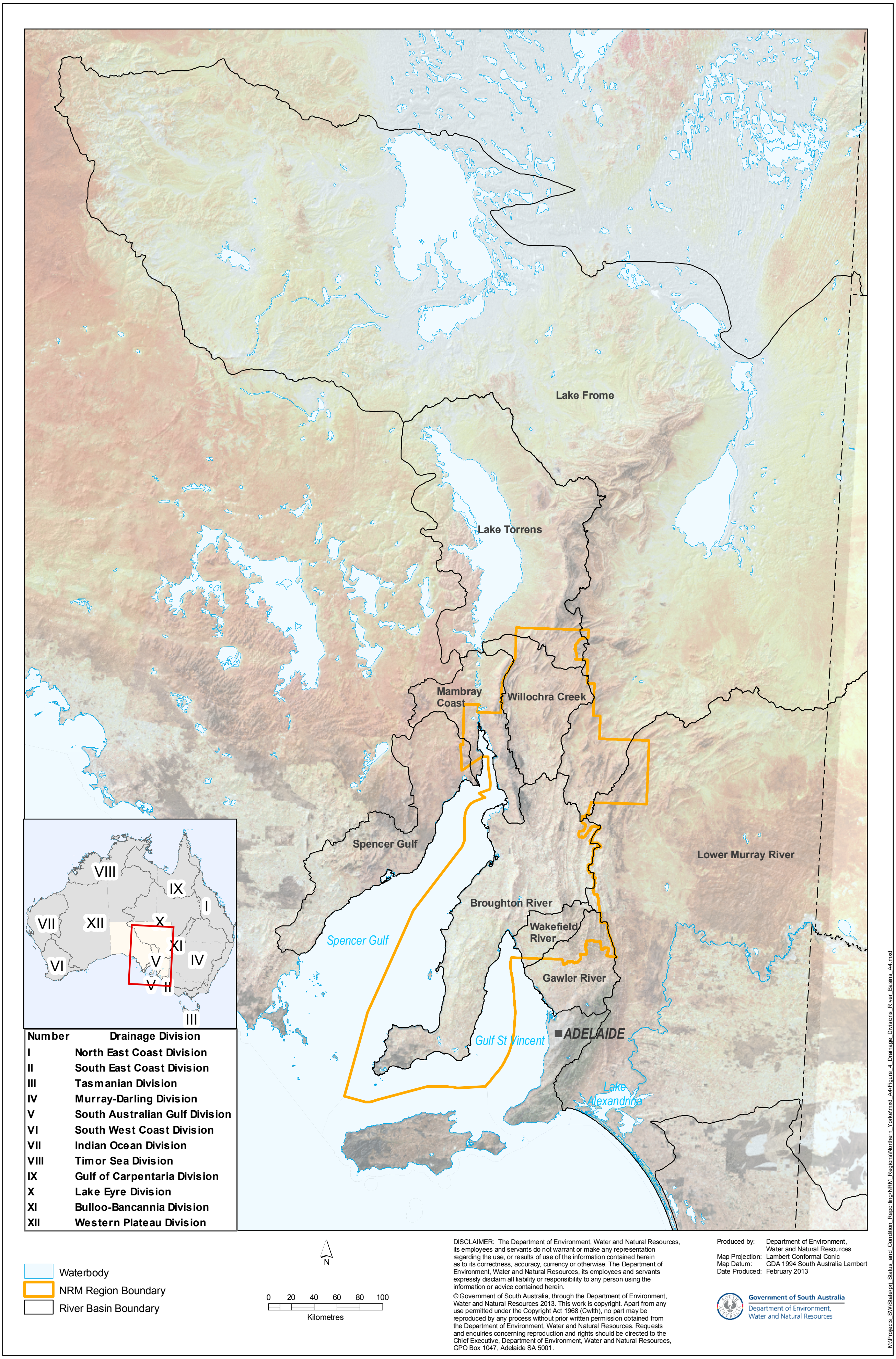
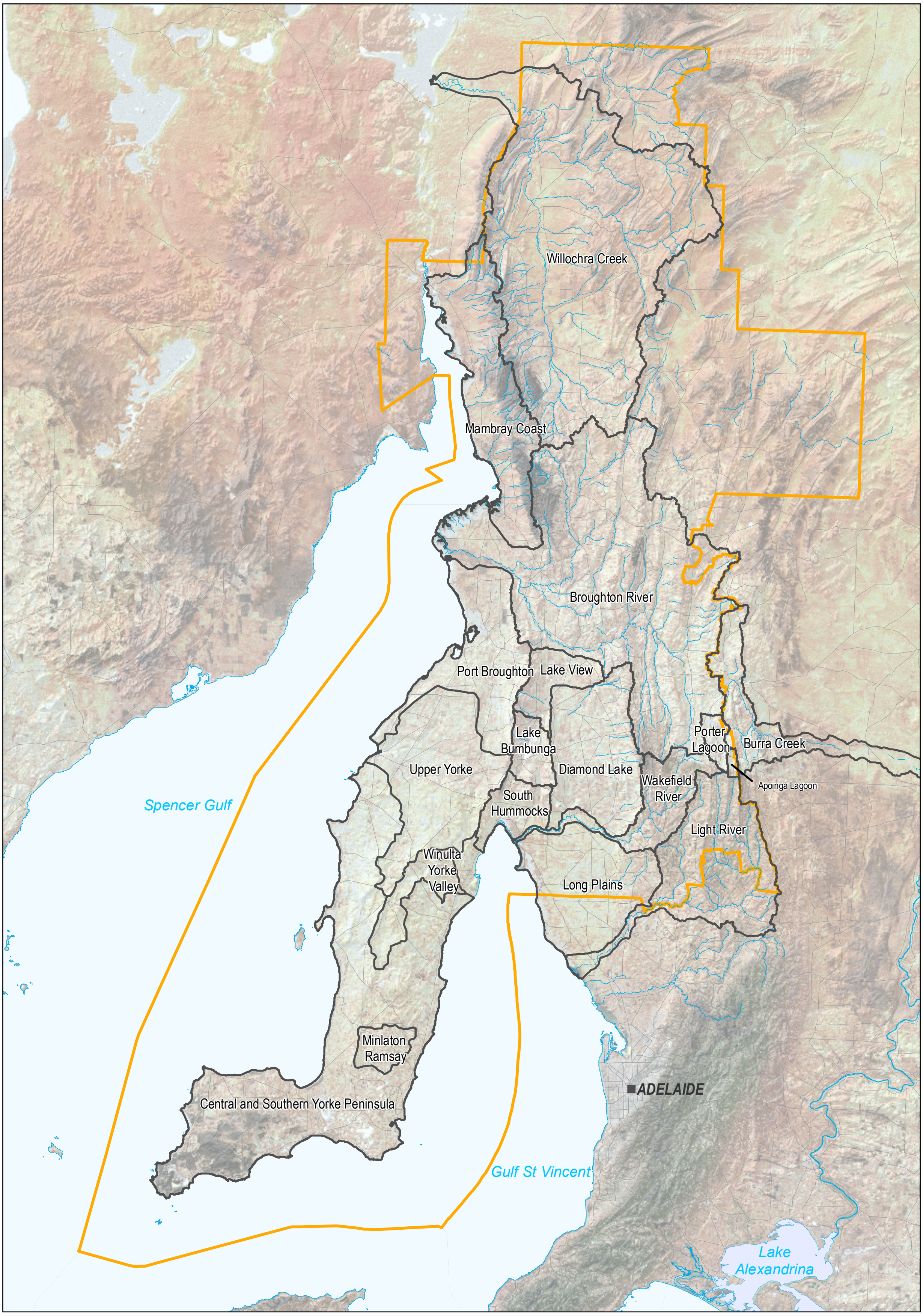


Figure 4. Drainage divisions and river basins



Road
Watercourse
NRM Region Boundary
Catchment Boundary

N

0 10 20 30 40 50
Kilometres

Produced by: Department of Environment, Water and Natural Resources
Map Projection: Lambert Conformal Conic
Map Datum: GDA 1994 South Australia Lambert
Date Produced: February 2013

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Department of Environment, Water and Natural Resources

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Figure 5. Surface water catchments of the Northern and Yorke NRM Region

2.3.1. Light River catchment

The Light River catchment is located about 50 km north of Adelaide and flows in a south-westerly direction to discharge into the Gulf St Vincent (Figure 6). Approximately half of the catchment is within the NRM region boundary and is bound to the north and west by the northern Mount Lofty Ranges. Larger townships include Saddleworth, Riverton, Kapunda and Hamley Bridge.

Based on rainfall data for the period 1900-2010, the average annual rainfall across the catchment ranges between 400 mm near the coast to 600 mm towards the south eastern margin near Kapunda.

The major watercourse of the catchment is the Light River, at approximately 170 km in length. The Light River rises in the north of the catchment near Waterloo where it flows south through Marrabel, Hamilton and Hansborough. From the junction between Light River and Gilbert River near Hamley Bridge, the Light River drains south-west to Gulf St Vincent. Main tributaries to the Light River include Gilbert River, Julia Creek and Tothill Creek, with the Gilbert River being by far the largest of these.

Topography varies in the catchment with elevations of 600 m above sea level in the north and west of the catchment. Undulating hills of the northern Mount Lofty Ranges provide numerous pathways for surface water runoff in the upper portions of the catchment. The Light River becomes a perched river system once it flows out from the gorge section below Hamley Bridge. There are no significant inflows downstream of Hamley Bridge.

According to VanLaarhoven *et al*. (2002), rainfall of greater than 450 mm is required to saturate the catchment and generate significant streamflows in the Light River. VanLaarhoven (2002) also noted that permanent groundwater-driven baseflow is evident in sections of Gilbert River, Julia River and Light River.

Currently, there are no active streamflow monitoring stations in the Light River catchment that is within the NRM region boundary. However, the station Light River at Mingays Waterhole, which is located in the portion of the catchment not within the NRM region, has been measuring streamflow since 1985. Another station, located a little further downstream nearer to Kapunda, was also operational from 1973 to 1989. This station was replaced by the Mingays Waterhole station.

Table 2. Catchment characteristics of the Light River catchment

Catchment Area	1750 km^2
Rainfall	400-600 mm
Topography	0-600 m
Subcatchments	6 – Gilbert River, Upper Light River, Julia Creek, Pine Creek, Mid Light River and Lower Light River
Monitoring	13 active rainfall monitoring stations 0 active streamflow monitoring stations

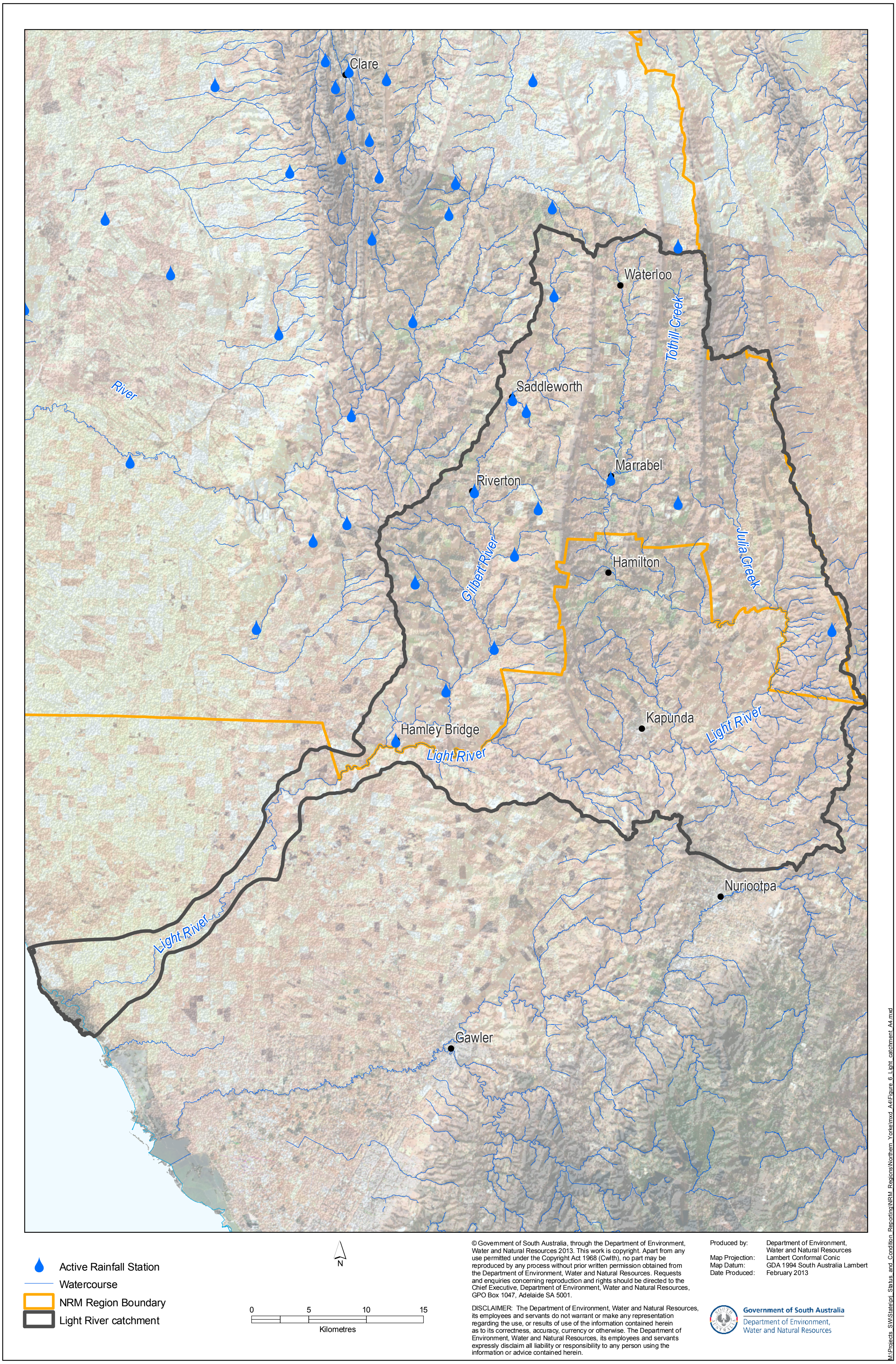


Figure 6. Detailed map of the Light River catchment

2.3.2. Broughton River catchment

The Broughton River catchment is the second largest catchment in the region and is located about 115 km north of Adelaide (Figure 7). The catchment is almost entirely located within the NRM region, excluding a small portion along the eastern catchment boundary. The larger townships include Port Pirie, Clare, Crystal Brook, Laura, Jamestown and Spalding. The higher relief areas of the catchment form parts of the Southern Flinders Ranges.

Based on rainfall data for the period 1900-2010, average annual rainfall across the catchment ranges between 300-700 mm. Rainfall is variable across the catchment, decreasing from east to west. The high relief areas of the southern and north-western parts of the catchment receive 600-700 mm, while coastal rainfall is between 300-400 mm.

The major watercourse of the catchment is the Broughton River, at approximately 145 km in length. The Broughton River commences in the east of the catchment, flowing west and draining to Spencer Gulf. Tributaries to the Broughton River include Rocky River, Hill River, Hutt River and Yackamoorundie Creek. Favier *et al.* (2004) attributes seasonal patterns of streamflow to variable rainfall, where high monthly streamflows occur between May and October, while low monthly streamflows occur between November and April. Groundwater is also thought to maintain baseflow along the Broughton River.

Topography of the catchment has higher elevations in the north, east and south. This directs watercourses to flow towards the centre of the catchment and then to the west. Elevations of more than 700 m above sea level are in the north and west of the catchment. Mount Bryan, just outside the eastern boundary of the catchment, stands at 940 m above sea level.

The Broughton River catchment has five active streamflow monitoring stations.

Table 3. Catchment characteristics of the Broughton River catchment

Catchment Area	5650 km^2
Rainfall	300-700 mm
Topography	0-750 m
Subcatchments	11 – Booborowie Creek, Bundaleer and Never Never Creeks, Crystal Brook, Farrel Flat and Baldry Creeks, Freshwater Creek, Hill River, Hutt River, Lower Broughton River, Mid Broughton River, Rocky River and Yackamoorundie Creek
Monitoring	42 active rainfall monitoring stations 5 active streamflow monitoring stations - Hill River near Andrews (A5070500), Hutt River near Spalding (A5070501), Broughton River at Mooroola (A5070503), Hutt River at Clare Caravan Park (A5070901) and Rocky River d/s Threadgolds Crossing (A5071002)

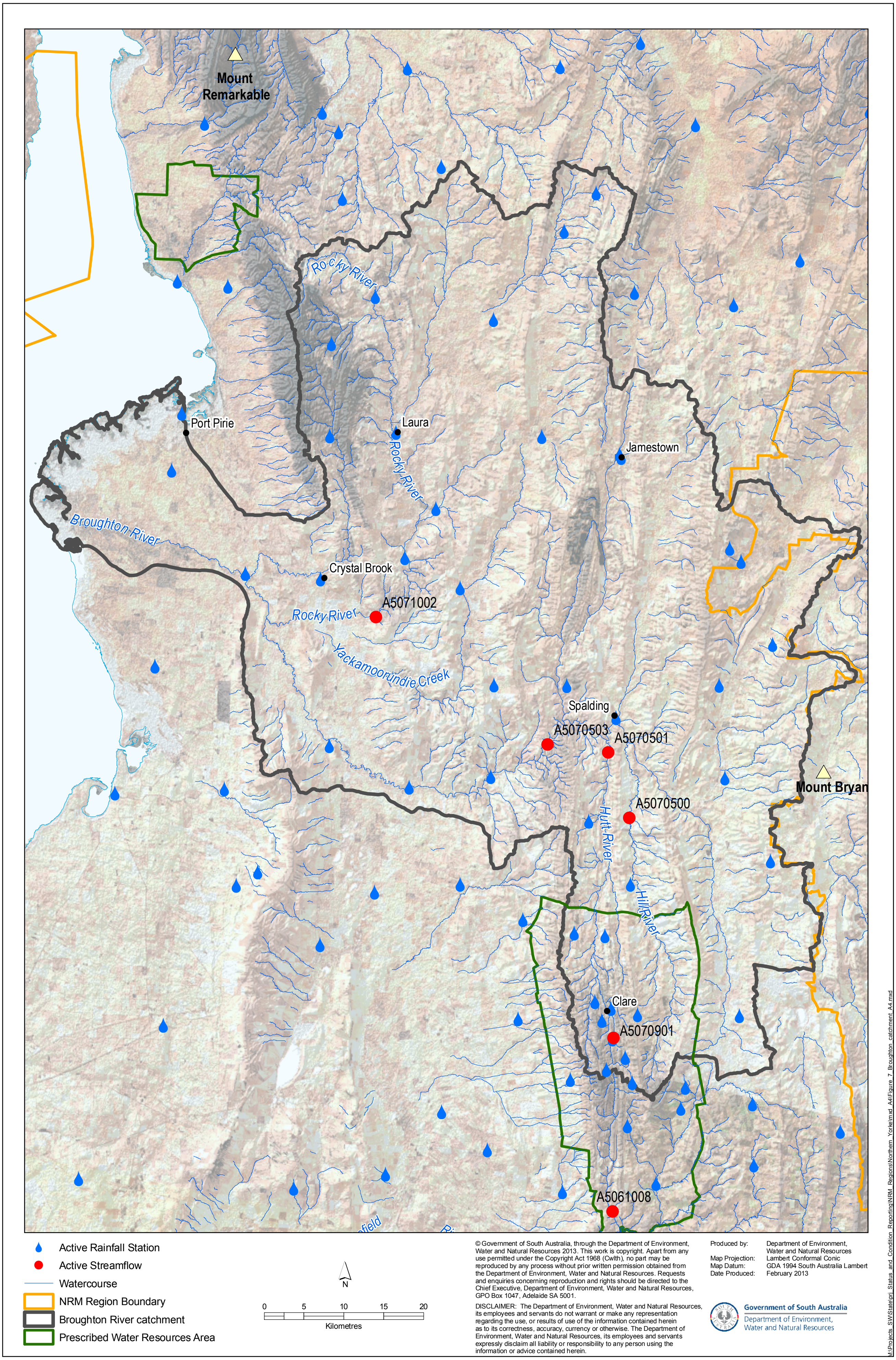


Figure 7. Detailed map of the Broughton River catchment

2.3.3. Wakefield River catchment

The Wakefield River catchment is located about 100 km north of Adelaide (Figure 8). Larger townships in the catchment area include Mintaro, Auburn, Balaklava and Port Wakefield.

Average annual rainfall across the catchment ranges between 350 mm at the coast to around 700 mm in the north of the catchment, based on rainfall data for the period 1900-2010. The higher rainfall in the ranges contributes to most of the streamflow, with the 300-350 mm of rainfall near the coast contributing very little except in cases of intense rainfall events which would produce more localised runoff.

The major watercourse of the catchment is the Wakefield River, at approximately 115 km in length. As with the Light River, Wakefield River flows south-west from the high relief areas of the northern Mount Lofty Ranges and then west, draining to Gulf St Vincent. Tributaries that contribute to the Wakefield River include Skillogalee Creek, Eyre Creek, Rices Creek and Pine Creek. The Wakefield River catchment is an ephemeral system, characterised by irregular streamflows and long dry intermediate periods. Groundwater driven baseflow maintains streamflow and permanent pools in the upper portions of the Wakefield River and sections of tributaries Skillogalee and Eyre Creeks (Favier *et al.* 2000).

Topography of the Wakefield River catchment is as high as 600 m above sea level in some northern parts of the catchment, reducing to around 300 m at the township of Auburn. When the Wakefield River reaches Balaklava, the elevation has reduced to around 65 m above sea level. The slope of the Wakefield River becomes much more gradual between Balaklava and the outlet to Gulf St Vincent.

There are two active streamflow monitoring stations in the catchment, monitoring streamflows along Skillogalee Creek and Wakefield River.

Table 4. Catchment characteristics of the Wakefield River catchment

Catchment Area	690 km^2
Rainfall	350-700 mm
Topography	0-600 m
Subcatchments	8 – Skillogalee Creek, Lower, Mid and Upper Wakefield River, Woolshed Creek, Rices Creek, Pine Creek and Eyre Creek
Monitoring	10 active rainfall monitoring stations 2 active streamflow monitoring stations - Wakefield River near Rhynie (A5060500) and Skillogalee Creek at Goodonga (A5061008)

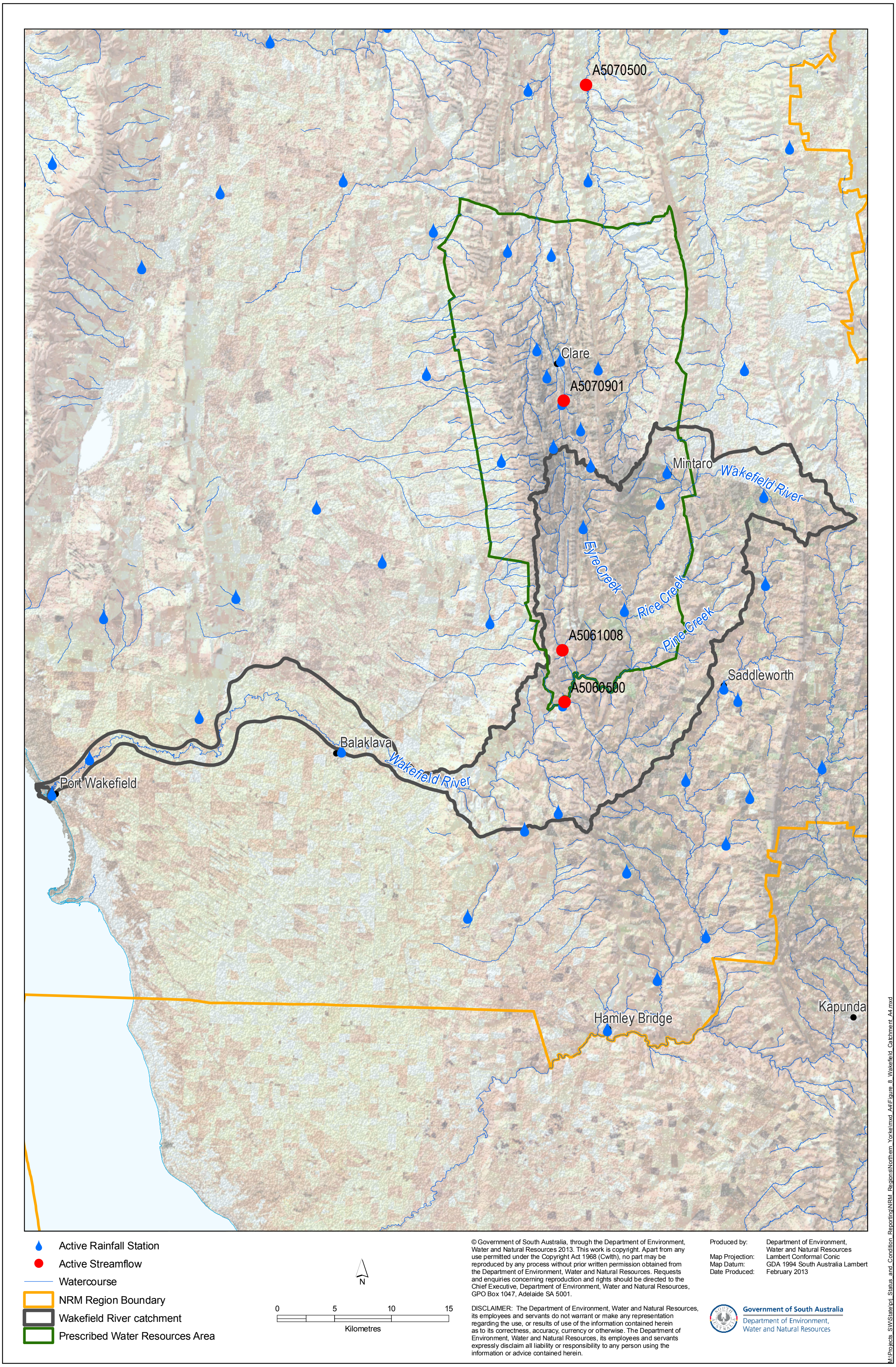


Figure 8. Detailed map of the Wakefield River catchment

2.3.4. Willochra Creek catchment

Willochra Creek catchment is the largest in the region, located about 250 km north of Adelaide (Figure 9). The southern half of the catchment is bound by the Southern Flinders Ranges while the northern half of the catchment from north of Quorn is bound by the Northern Flinders Ranges. The catchment flows in a northerly direction to drain to Lake Torrens. Larger townships include Melrose, Wilmington, Quorn and Willochra.

The distribution of rainfall over the Willochra Creek catchment is between 200-800 mm (based on rainfall data for the period 1900-2010). Areas of higher rainfall around Mount Remarkable in the south of the catchment receive about 765 mm. Rainfall over the central part of the catchment varies between 200-400 mm. The small area in the north-west of the catchment, near the Willochra Creek outlet to Lake Torrens, receives the lowest average rainfall of approximately 200 mm.

Willochra Creek is the major watercourse at approximately 210 km in length. Willochra Creek commences in the south of the catchment near the township of Melrose and Mount Remarkable, flowing north through the townships of Bruce, Willochra and Warrakimbo and into Lake Torrens. Major tributaries that contribute to Willochra Creek include Booleroo Creek in the south of the catchment, Boolcunda Creek in the central part of the catchment and Kanyaka Creek in the north. The ephemeral Willochra Creek has reliable streamflow only during the winter months, but this reliable streamflow is more prominent in the lower reaches of the catchment (Risby *et al*. 2003). This reliable streamflow is understood to be generated by baseflow.

Willochra Creek catchment is bound by higher elevations along the western, southern and eastern boundaries and decreasing towards the centre of the catchment. Mount Remarkable in the south of the catchment has an elevation of almost 950 m above sea level. Mount Arden and Mount Brown, which are along the western boundary of the catchment, have elevations of around 830 m and 960 m above sea level respectively. The outlet of Willochra Creek to Lake Torrens is approximately 30 m above sea level.

The two active streamflow stations in the catchment monitor streamflows along Kanyaka Creek in the north and Spring Creek in the south. There is no streamflow monitoring station along Willochra Creek itself.

Table 5. Catchment characteristics of the Willochra Creek catchment

Catchment Area	6400 km^2
Rainfall	200-800 mm
Topography	30-960 m
Subcatchments	10 defined for the southern half of the catchment (Risby *et al.* 2003) – Beautiful Valley, Booleroo Creek, Campbell Creek, Fullerville, Old Booleroo Creek, Spring Creek, Stony Creek, Wild Dog Creek, Willochra Creek and Yellowman Creek
Monitoring	20 active rainfall monitoring stations 2 active streamflow monitoring stations – Kanyaka Creek (A5090503) and Spring Creek (A5091002)

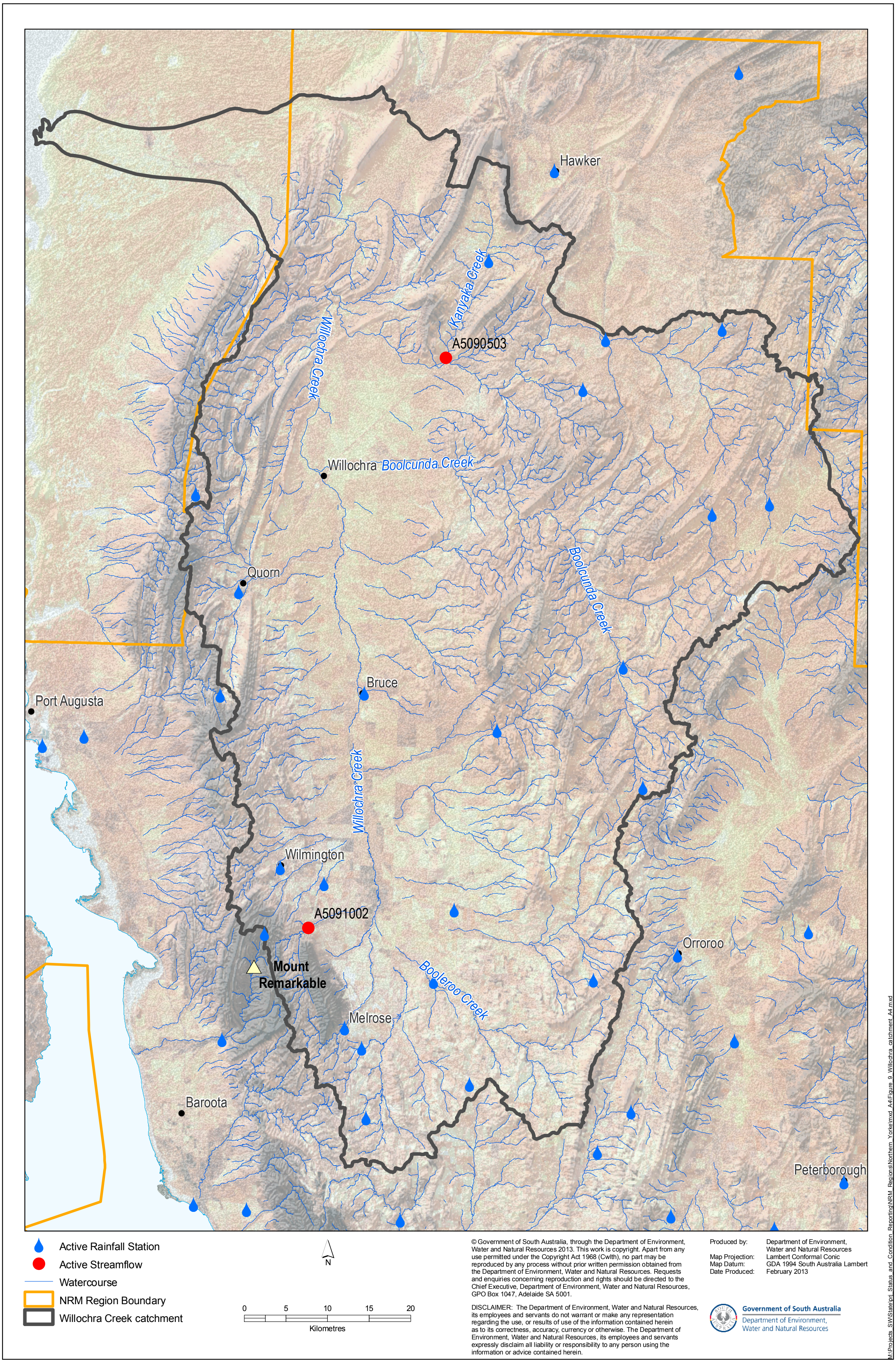


Figure 9. Detailed map of the Willochra Creek catchment

2.4. Land use

The predominant land uses across the region are grazing and cropping (Table 6). Barley, wheat and oats are the principal focus of primary production. The region also includes the internationally recognised viticulture and winemaking area of the Clare Valley. Mining, mineral processing, forestry, fishing, aquaculture and tourism are other important industries for the region's current and future economic prospects.

The underlying geology influences the run-off of surface water in the regions three major landforms; Yorke Peninsula, the coastal plains, and the ranges and valleys of the northern Mount Lofty Ranges and Southern Flinders Ranges. The soils of Yorke Peninsula are largely loam over clay, shallow calcrete or calcareous loams with areas of dunefields and saline land. Shallow calcrete and calcareous loams are also characteristics of the coastal plains, as well as dune-swale and sand spread complexes. Neutral loamy soils over red clay subsoils, which are highly susceptible to water erosion, are characteristics of the northern Mount Lofty Ranges and Southern Flinders Ranges (NYNRMB 2009a).

Although fragments of native vegetation which support significant biodiversity have been retained in places across the region, nearly two-thirds of the region's native vegetation has been cleared. Declining soil health, pests and diseases are recognised as processes which limit primary production across the region. Diversions of surface water and groundwater have altered natural water regimes. Across the region, it is estimated that around 30 000 hectares (300 km^2) of land is affected by secondary salinity (i.e. salinity arising from human induced changes) (NYNRMB 2009a). The Northern and Yorke NRM Board cite sustainable crop management and grazing practices as becoming a major focus, with increasing awareness of the role of native revegetation in stabilising soils and reducing impacts of shallow-groundwater induced salinity (NYADINRMC 2003).

Table 6. Land use summary of the Northern and Yorke NRM Region

Land use	Area (ha)	%
Grazing (modified pasture)	1 686 373	47.7
Cropping	1 542 210	43.7
Grazing (native vegetation)	198 095	5.6
National parks / reserves / recreation	62 583	1.8
Vineyards	9321	0.3
Forestry	7661	0.2
Residential (rural)	6179	0.2
Water body	5787	0.2
Residential (urban)	5588	0.2
Quarries	2897	0.1
Horticulture (annual)	1551	0.0
Public service	1454	0.0
Horticulture (perennial)	1060	0.0
Mining/manufacturing/industrial	809	0.0
Airports	740	0.0
Piggery	401	0.0
Waste disposal site	252	0.0
TOTAL	**3 532 961**	**100**

2.5. Demand for water resources

2.5.1. Towns and agriculture

Surface water and groundwater resources are essential in maintaining the social fabric and economic viability of the region. Many townships and homesteads rely heavily on captured rainwater and groundwater for stock and domestic water supplies. Surface water resources play a crucial role in the conservation of the natural biodiversity of the area and management plans have been completed for the Wakefield, Light and Broughton Rivers (NYNRMB 2009a). All watercourses in the Mid North region—from Hamley Bridge to Port Augusta—exhibit ephemeral or intermittent streamflow regimes. Yorke Peninsula shows far less drainage expression, with most of the rainfall runoff collected in landlocked, saline lagoonal systems (NYNRMB 2009a).

Early expansion of the agricultural sector resulted in increasing demand for water across the region, primarily for stock and domestic uses. Water supply problems associated with increases in demand were temporarily mitigated by the construction of a reservoir at Baroota in 1921. Water resources are scarce in the region, especially in the north. To ensure water supplies to the regional centres of Whyalla, Port Augusta and Port Pirie, the Morgan-Whyalla pipeline was constructed between 1940 and 1944 (DWR 2000).

Two PWRAs are located within the region. Clare PWRA is approximately 100 km north of Adelaide and is well known for viticulture and wine production, relying on irrigation from dams, watercourses, groundwater and imported River Murray water from the SA Water Clare Valley Water Supply Scheme. The northern half of the PWRA drains to Spencer Gulf via the Broughton River while the southern half drains to Gulf St Vincent via the Wakefield River. The Clare PWRA WAP (2009) states there are 1435 farm dams within the PWRA with an estimated capacity of 6451 ML. The status of surface water resources in the Clare PWRA is described in a Surface Water Status and Condition Report prepared for this area (available online: http://www.waterconnect.sa.gov.au).

The Baroota PWRA is approximately 25 km north of Port Pirie on the coastal plains between the Southern Flinders Ranges and Spencer Gulf in the State's Mid North. Baroota PWRA was prescribed in 2008, following large increases in irrigation demand in the Baroota area in the late-1990s. The PWRA includes the Baroota Reservoir and some of its catchment as well as the area below the reservoir towards the coast. Baroota Creek is the major watercourse downstream of the reservoir and drains to Spencer Gulf near Port Germein. The reservoir, with a capacity of 6140 ML, was used as a balancing storage for the reticulation of River Murray pipeline water up until 1997. Monitoring of water levels at the reservoir ceased at the end of 2010. Approximately 17 farm dams are within the Baroota PWRA, which are used for stock and domestic purposes.

Across the region, water supplies are sourced from watercourses, farm dams, the River Murray, desalination and local groundwater resources. River Murray water is the major water resource to the region and in 2011 this was estimated at 31.8 GL (DFW 2011). Most townships across the region are serviced by SA Water reticulation schemes. Water from the River Murray is distributed via the Morgan-Whyalla and Swan Reach pipelines, supplying Port Pirie, Clare, Jamestown and parts of Yorke Peninsula.

Reticulated potable water for Yorke Peninsula comprises three water supply systems:

1. The Upper Paskeville system which supplies River Murray water to most of the region south of Paskeville down to the southern townships of Yorketown and Edithburgh
2. The Lower Paskeville system which supplies River Murray water to the Copper Coast region – a region of South Australia situated in northern Yorke Peninsula – including the townships of Wallaroo, Kadina and Moonta
3. The stand-alone Warooka system, which supplies the southern townships of Warooka and Point Turton, from groundwater resources within the Para-Wurlie groundwater basin.

Meeting increasing demand for water by Yorke Peninsula's coastal settlements is constrained by the central location of the Upper Paskeville trunk main. Many coastal landowners still rely on rainwater for potable supply. There are 22 existing settlements across Yorke Peninsula which lie outside SA Water's potable, reticulated supply system (SA Water 2010). Marion Bay Council recently commissioned a small-scale desalination plant for town water supply in response to increasing community concern over water security.

Other localities in the north of the region (e.g. Orroroo, Hawker, Quorn, Wilmington and Melrose) rely on local groundwater resources for their town water supply. Deane and Graves (2008) estimated there are approximately 8800 farm dams in the region. Other water resources include the Beetaloo and Bundaleer reservoirs, and recycled water. Lagoons and freshwater wetlands are also a feature in the landscape but not generally utilized as a resource.

2.5.2. Mining

Significant mineral-based industries are located at Port Augusta and Port Pirie (mainly silver, lead and zinc smelting). Mineral exploration activity is increasing across Yorke Peninsula. Numerous mineral production tenements and mineral production tenement applications, as well as many exploration licenses and exploration license applications, exist across the region. Notable development projects include the Hillside Prospect (copper-gold) and the Clinton Project (coal-biomass-to-liquid). In the Mid North, some diamond exploration activity is occurring east of Peterborough and a significant copper-gold resource has been discovered near Olary. There are numerous small-scale mining developments across the region. These are mostly pits and quarries for non-mineral commodities (e.g. sand, sandstone, slate, granite, gypsum and salt). Related water-use activities could potentially impact on the regions potable and/or non-potable groundwater resources.

2.5.3. Balancing demand and supply

A key commitment in *Water for Good* is the development of Regional Demand and Supply Statements, the first of which has been released for the Eyre Peninsula region (DFW 2011a). The Northern and Yorke Demand and Supply Statement (DFW 2011) is now also available (http://www.environment.sa.gov.au). The Demand and Supply Statements ensure that long-term water security solutions for each region are based on a thorough understanding of the state of all local water resources, the demand for these resources and the likely future pressures. The Demand and Supply Statements provide demand and supply projections for the scenarios of high and low population growth and high and low greenhouse gas emission. Two projection sets address the demand and supply for (1) drinking quality water only and (2) for all water sources and human demands.

The River Murray is the major source of water for the region. DFW (2011) estimated River Murray water use in the region to be 31.8 GL. Surface water uses, which includes watercourse water and farm dams, was estimated to be 12 GL, and groundwater 5.5 GL. The main sectors of water source usage (both potable and non potable) for the region include domestic use, stock use, irrigation, industrial and commercial. There is considerable evidence that significant growth of the mining industry will occur in the State over the next 40 years (e.g. Government of South Australia 2011; RESIC 2010). Mining operations require significant volumes of water, but can typically be of a lower quality than is required for stock or irrigation. A report prepared for the Resources and Energy Sector Infrastructure Council (Parsons Brinckerhoff 2011) highlighted that water demand across the State's resource sector will increase from approximately 40 GL in 2011 to over 170 GL per annum from 2017. The majority of this increase will be sourced from non-potable water supplies. It is important that associated water resource demands are considered, planned for and managed, while balancing this against environmental and social requirements.

3. Data summary

3.1. Rainfall

Rain tends to fall predominantly in the winter months across the region. The higher magnitude of rain tends to fall across the central part of the region, followed by Yorke Peninsula. The northern part of the region experiences the least amount of rainfall. The central part of the region includes the higher elevated areas of the northern Mount Lofty Ranges and the Southern Flinders Ranges. Rainfall across this part of the region varies between 400-800 mm. The Yorke Peninsula area and upward to Port Pirie receives between 300-500 mm on average. The southern-most part of Yorke Peninsula has slightly higher average rainfall just above 500 mm. The northern-most part of the region is the driest with rainfall on average predominantly between 200-300 mm. Isolated parts of the north receive 300-400 mm.

The distribution of rainfall monitoring stations in the region varies, with approximately 100 active stations in the southern half of the region compared to approximately 60 in the northern half. Length of rainfall records available from these sites varies, but more than 60% of active monitoring stations have more than 50 years of recorded data and just fewer than 50% of active stations have more than 100 years of data. The oldest station is the Brinkworth (Bungaree) BoM rainfall station, which was established in 1859.

3.1.1 Spatial and temporal variation

To analyse the spatial variation of rainfall in the region, four stations were selected to represent the rainfall patterns and trends across the region. These stations are highlighted red in Figure 10. The stations are located at the base of Yorke Peninsula at Warooka, the lower and upper central part of the region at Saddleworth and Melrose, and in the regions north at Hawker. The selected stations have well over 100 years of data and show low, medium and high rainfall areas representative of the region. The period of record at each station has been summarised from 1889-2011 to ensure a consistent comparison of years (Table 7).

Table 7. Selected rainfall analysis sites in the Northern and Yorke NRM Region

Rainfall Station	Station No.	Period of Record	Average Annual Rainfall (mm)
Warooka	M022018	1889-2011	443
Saddleworth	M023315	1889-2011	486
Melrose	M019024	1889-2011	559
Hawker (Wilson)	M019050	1889-2011	302

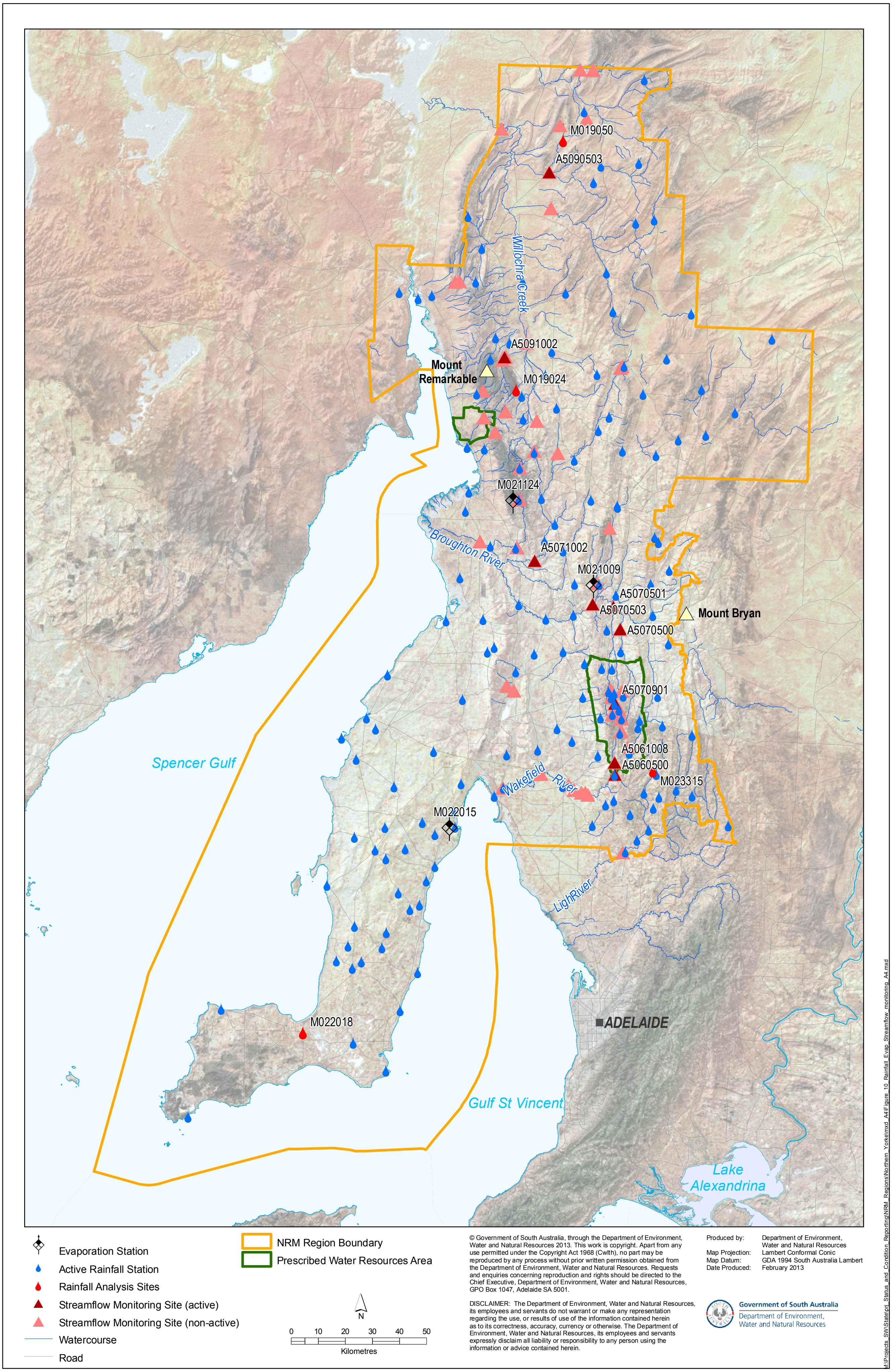


Figure 10. Rainfall, streamflow and evaporation monitoring stations of the Northern and Yorke NRM Region

Annual rainfall records vary when comparing the four rainfall sites. The cumulative deviation from mean annual rainfall (residual mass curve) identifies periods of above and below average trends. An upward slope in a residual mass curve indicates a period of wetter-than-average rainfall, while a downward slope indicates a period of drier-than-average rainfall. Graphs illustrating rainfall distributions and patterns over the period of record for each of the four reference stations are provided below, along with a brief description highlighting key points of interest in the data sets.

Data from Warooka BoM rainfall station are summarised for the period 1889 to the end of 2011 in Figure 11. The 123 years of data have an average annual rainfall of 443 mm. A simple linear trend analysis indicates that there is no significant trend in annual rainfall across the period of record. After a period of low rainfall to the early 1900s, rainfall at Warooka was wetter-than-average to the early 1920s, before a period of approximately 20 years of drier-than-average rainfall. Rainfalls increased again between 1940 and the late 1950s before a period of around average rainfall to the mid 1970s. From the mid 1970s rainfall was again drier-than-average before recovering in the early 1990s. The drought period from 2000 shows a declining rainfall trend with some recovery seen in the last few years to 2011. The distribution of monthly rainfall at Warooka shows rainfall predominantly during the winter months (Figure 12). Whilst not wanting to understate the impact of the 2000 drought period, historically there have been longer periods of below average rainfall and drier years.

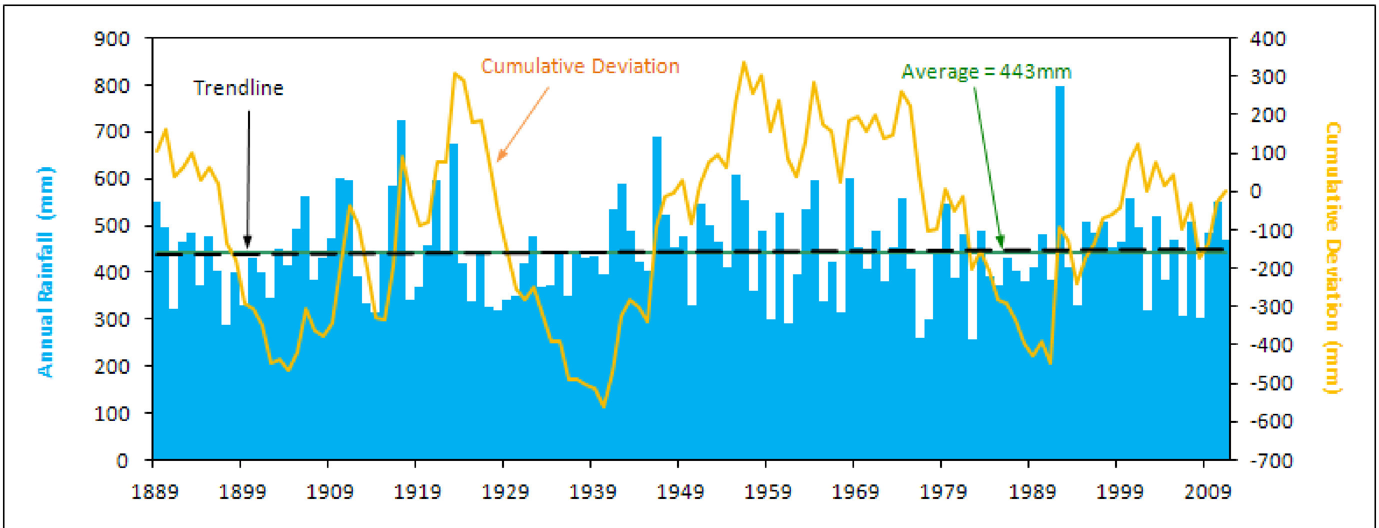


Figure 11. Annual rainfall: Warooka BoM rainfall station

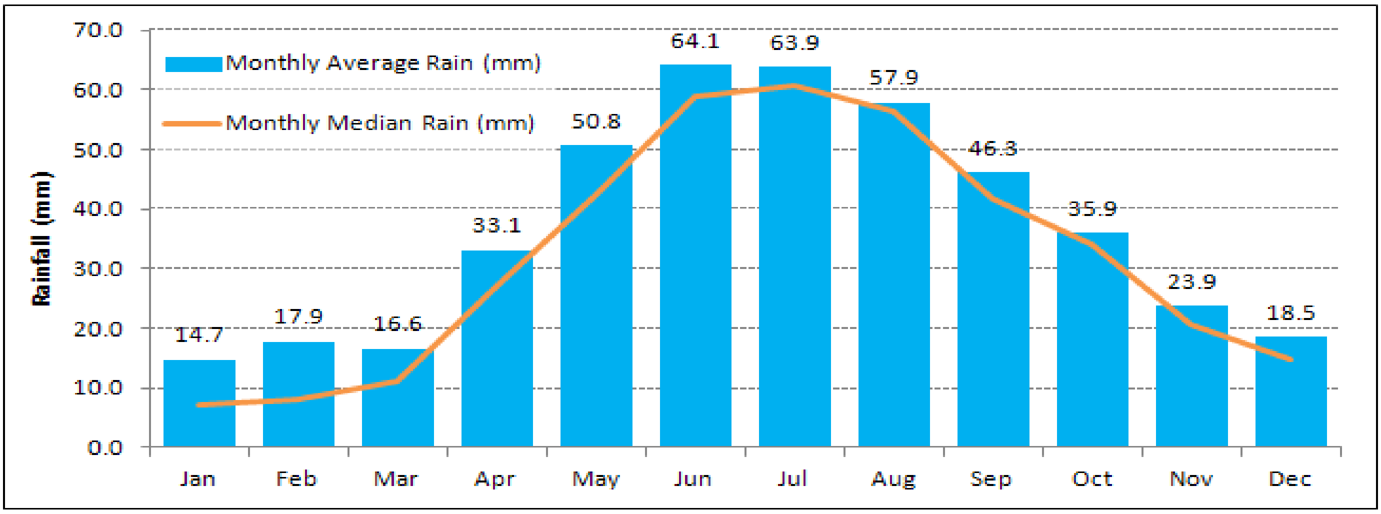


Figure 12. Mean and Median monthly rainfall: Warooka BoM rainfall station

Data from Saddleworth BoM rainfall station are summarised for the period 1889 to the end of 2011 in Figure 13. The 123 years of data have an average annual rainfall of 486 mm and displays a trendline slightly decreasing across the data period. In comparison to Warooka, Saddleworth is located in a higher elevation, and its rainfall records display a different pattern of wet and dry periods. After a series of wet and dry years between 1900 and 1930, Saddleworth experienced around 30 years of wetter-than-average rainfall to the late 1950s before another dry period. From 1970 to 2011, rainfall around Saddleworth has fluctuated between a few very-wet years and a few well-below-average annual rainfalls. The distribution of monthly rainfall at Saddleworth shows rainfall predominantly during the winter months (Figure 14). The monthly average in all months excluding June and July is higher than those at Warooka. There is also less variation between monthly average and monthly median rainfall which suggests less variable monthly rainfall at Saddleworth.

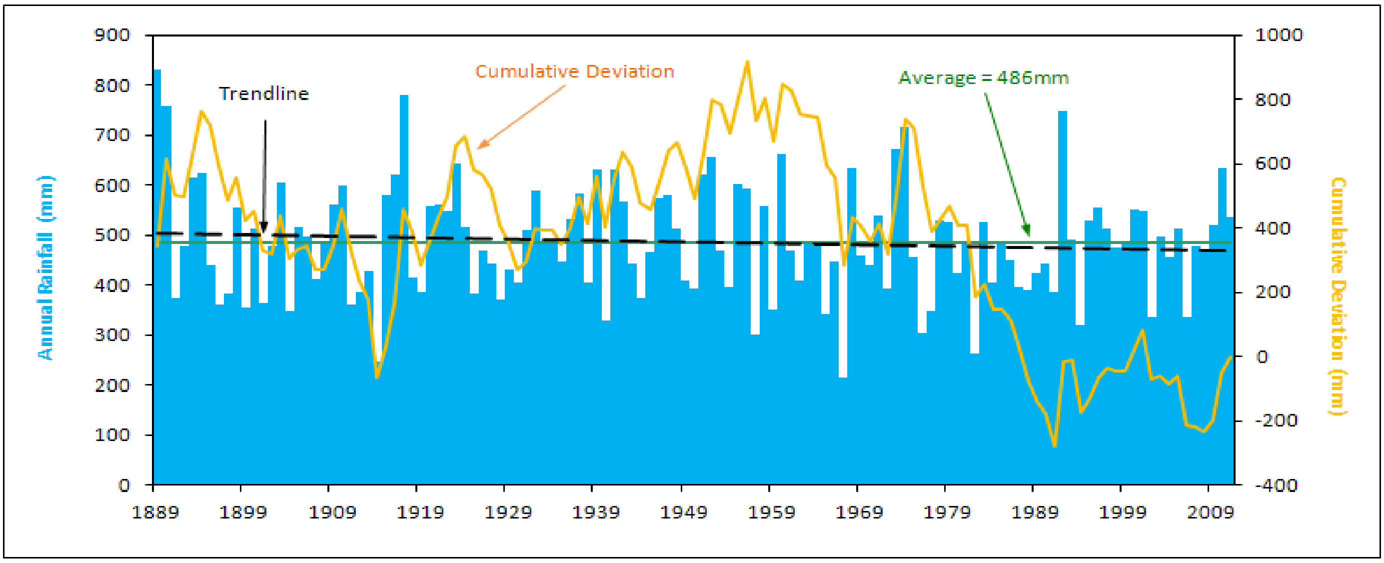


Figure 13. Annual rainfall: Saddleworth BoM rainfall station

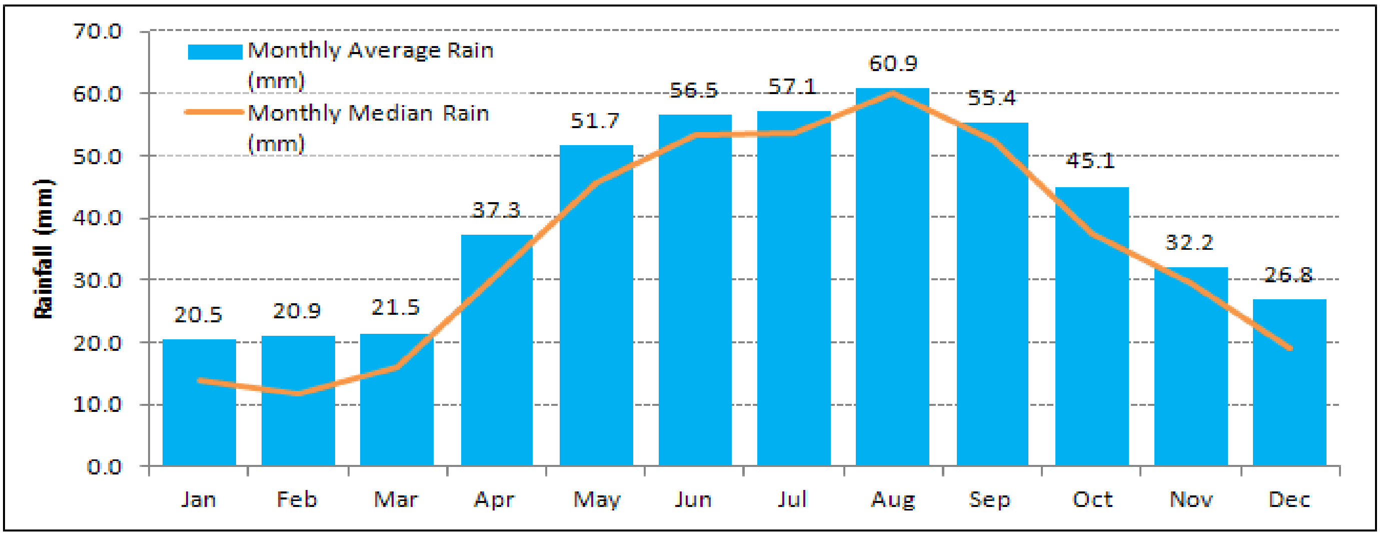


Figure 14. Mean and Median monthly rainfall: Saddleworth BoM rainfall station

Data from Melrose BoM rainfall station are summarised for the period 1889 to the end of 2011 in Figure 15. The 123 years of data have an average annual rainfall of 559 mm. A simple linear trend analysis indicates that there is no significant trend in annual rainfall across the period of record. The annual rainfall across the data period shows large fluctuations between well-above and well-below-average annual rainfall. Steep declines showing drier-than-average rainfall periods are shown between 1895-1905, 1910-15, 1925-45 and 1960-67. The fluctuation between wetter-than-average and drier-than-average rainfall was less prominent between the mid 1970s to early 2000s. After a number of drier-than-average years throughout the early 2000s, which coincide with recent drought conditions, Melrose has recorded above average rainfall over the past few years. The distribution of monthly rainfall at Melrose is similar to Warooka and Saddleworth in that higher rainfalls occur during the winter months (Figure 16). However, Melrose receives higher monthly average rainfall during the summer months, and monthly rainfall appears to be more variable.

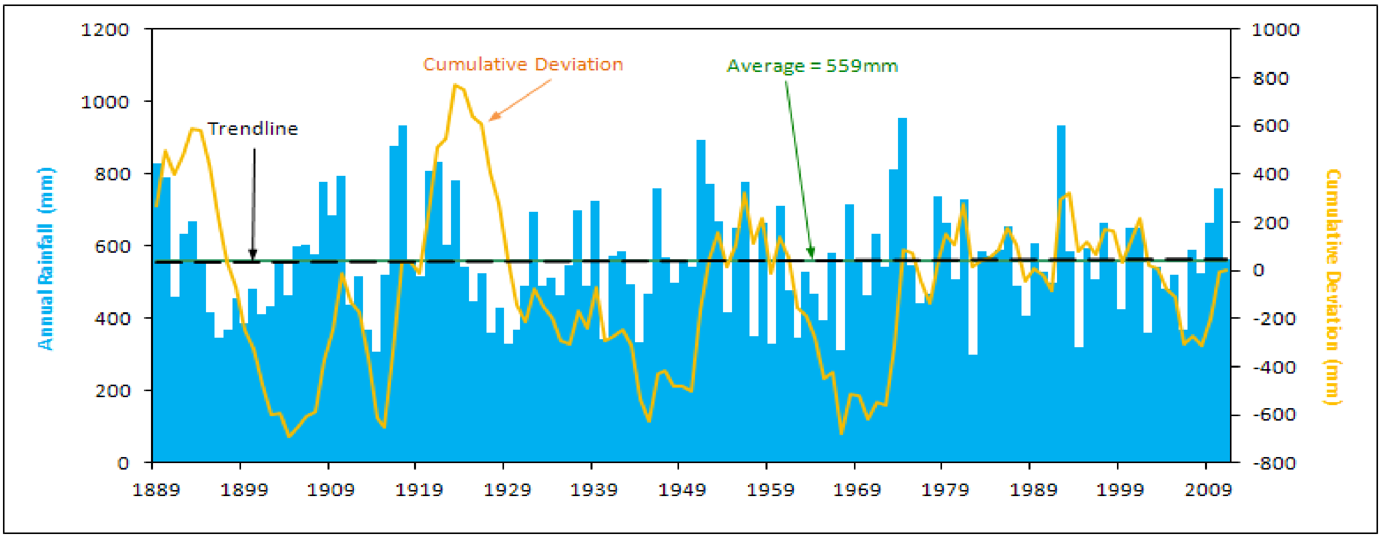


Figure 15. Annual rainfall: Melrose BoM rainfall station

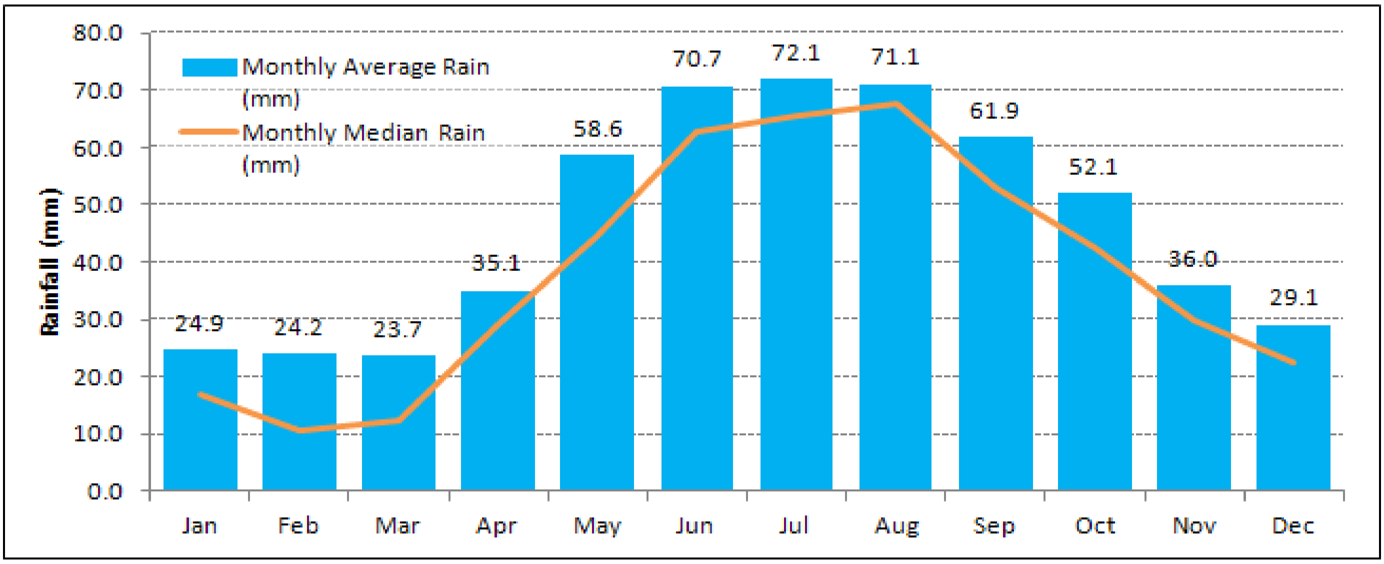


Figure 16. Mean and Median monthly rainfall: Melrose BoM rainfall station

Data from Hawker BoM rainfall station are summarised for the period 1889 to the end of 2011 in Figure 17. The 123 years of data have an average annual rainfall of 302 mm and displays a slightly increasing trendline across the data period. Rainfall at Hawker is highly variable with years of wetter-than-average rainfall followed with drier-than-average rainfall. Located further north in the region and more inland from the sea, this station receives lower rainfall compared to other parts of the region. Steep declines showing drier-than-average rainfall periods are shown between 1895-1902 and 1925-65. A period of around average rainfall occurred from 1945-58. The past 40 years from the early 1970s has seen average annual rainfall increase compared to the record prior to the 1970s which fluctuated largely. The distribution of average monthly rainfall throughout the year at Hawker is more uniform than the stations mentioned previously (Figure 18). This more uniform rainfall distribution reflects Hawker is more arid in nature and that it relies on moisture feeds from the north east and north west tropical areas of Australia for a significant portion of its rainfall.

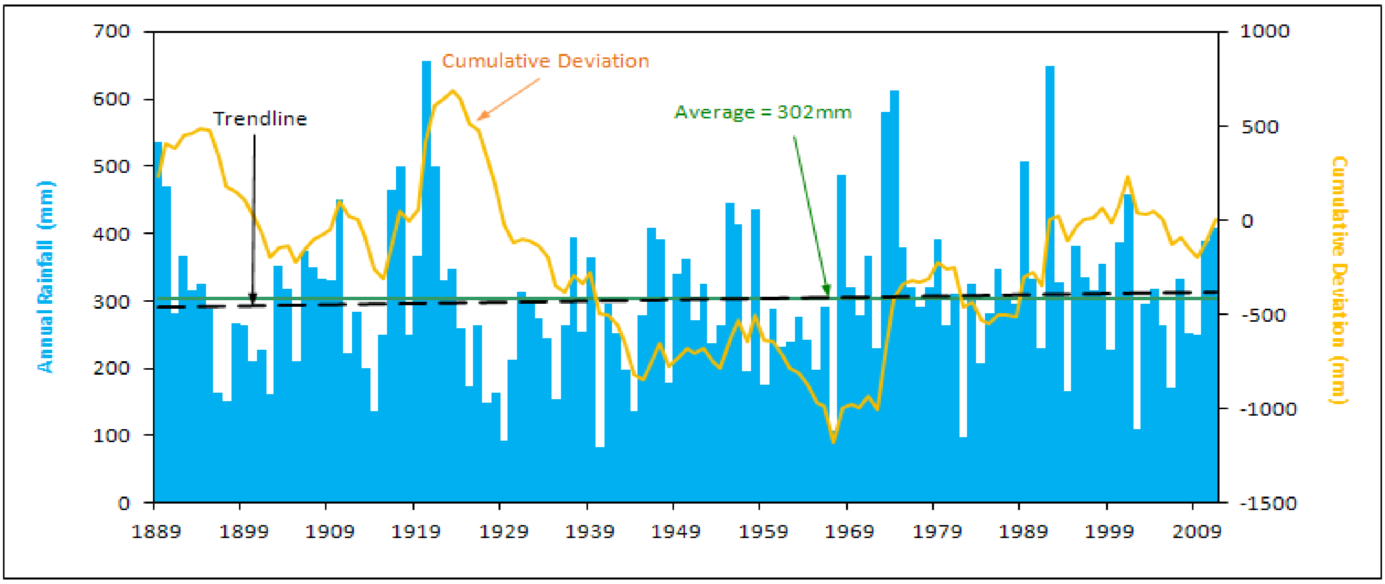


Figure 17. Annual rainfall: Hawker (Wilson) BoM rainfall station

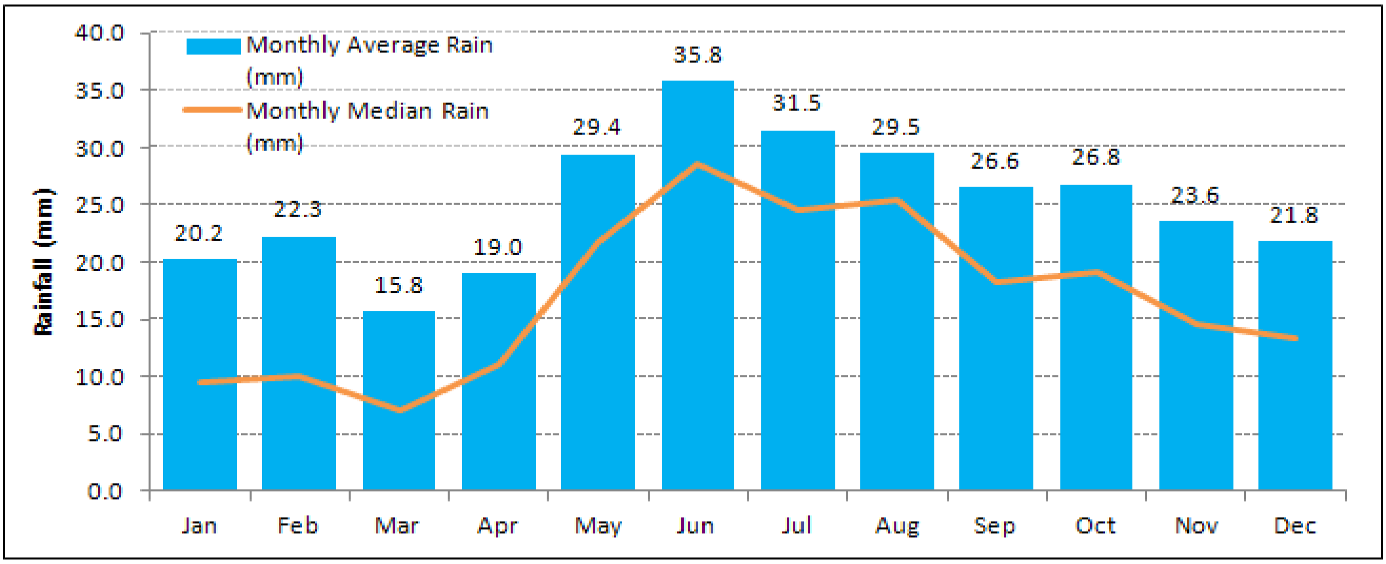


Figure 18. Mean and Median monthly rainfall: Hawker (Wilson) BoM rainfall station

3.2. Streamflow

The majority of streamflow in the region is generated from the higher elevation areas associated with the northern Mount Lofty Ranges and Southern Flinders Ranges. Watercourses in these areas discharge into either the Spencer Gulf, the Gulf St Vincent or Lake Torrens. Outside of these higher elevation areas drainage definition is poor. For example on Yorke Peninsula there is minimal drainage definition, with smaller surface water catchments terminating into landlocked lagoonal (saline wetland) features, whilst many smaller watercourses emanating from foothills of the main ranges spread out across alluvial fans and do not reach the coast. Watercourses in the region are ephemeral or have intermittent streamflow regimes; this includes even the major watercourses such as the Wakefield River, Light River, Willochra Creek and watercourses of the Mambray Coast.

Streamflow monitoring across the region is limited to nine active monitoring stations (Table 8 and Figure 10). Along with average annual streamflow for stations presented in Table 8, median streamflow and coefficient of variation is also given. The average coefficient of variation for streams in Australia is 0.70 (Grayson et al. 1996), with most coefficients in this region being well above one indicating a highly variable, boom and bust style of annual streamflow regime. The Wakefield River catchment has two active gauging stations, one on Skillogalee Creek and the other on Wakefield River near Rhynie. Broughton River catchment has five active gauging stations recording streamflows on Hill River near Andrews, Hutt River near Spalding, Broughton River at Mooroola, Hutt River at Clare Caravan Park and Rocky River downstream of Threadgolds Crossing. The remaining two active gauging stations in the region are located in the Willochra Creek catchment at Kanyaka Creek and Spring Creek.

Table 8. Active streamflow gauging stations in the Northern and Yorke NRM Region.

Gauging Station	Station No.	Catchment Area (km^2)	Period of Record	Average Annual Streamflow (ML)	Average Annual Streamflow (mm)	Median Streamflow (ML)	Coefficient of Variation (C_v)
Wakefield River near Rhynie	A5060500	416	1972 – 2011	6869	16.5	4443	1.14
Skillogalee Creek	A5061008	62	2004 – 11	213	3.4	88	1.61
Hill River	A5070500	235	1970 – 2011	4104	17.5	2840	1.23
Hutt River near Spalding	A5070501	280	1970 – 2011	5944	21.2	3665	1.29
Broughton River at Mooroola	A5070503	2470	1972 – 2011	26 087	10.6	16 210	1.00
Hutt River at Clare Caravan Park	A5070901	22	2010 – 11*	-	-	-	-
Rocky River D/S Threadgolds Crossing	A5071002	1224	2004 – 11	495	0.4	500	0.62
Kanyaka Creek at Old Kanyaka Ruins	A5090503	187	1978 – 2011	610	3.3	142	1.53
Spring Creek U/S Willowie Forest	A5091002	53	2004 – 11	880	16.7	586	1.25

*Site has been active for two years only and has large amounts of missing data.

The long-term average annual streamflow (1972-2011) for the Wakefield River is 6869 ML (Figure 19). Records date back to 1941, but include large periods of missing data. Records from 1972 are more reliable with limited days of data missing. For the purpose of this assessment, "Years with Missing Data" (green columns in Figures 19 to 26) are those with more than 30 days of data missing during winter, when majority of flow usually occurs. Some of the larger-streamflow years for Wakefield River include 24740 ML in 1974 and 37570 ML in 1992, with both years well exceeding the long-term average streamflow. The lowest of 686 ML was recorded in 1977. From 1982-91, Wakefield River recorded below average streamflows. From 2002-09, Wakefield River experienced well below long-term average streamflows, with the average across this period being 1640 ML. Streamflows returned to the river in 2010 with 12100 ML recorded for the year. Annual streamflow of 850 ML was recorded in 2011, significantly lower than the long term average and the third lowest total recorded since 1972.

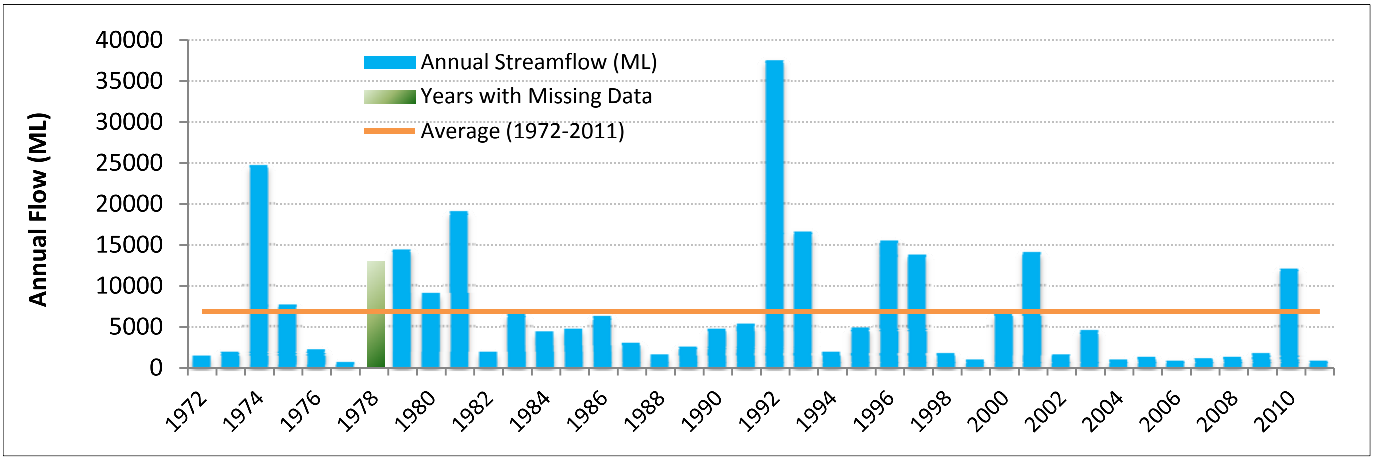


Figure 19. Annual streamflow record for the Wakefield River

Skillogalee Creek has annual streamflow data for 2004-11 with an average annual streamflow of 213 ML (Figure 20). The average streamflow for this period has been inflated somewhat by a large streamflow event in 2010, which boosted annual streamflow to 1045 ML in that year. If this year was removed from the record, the average would be around 80 ML per annum. The lowest streamflow year of 16 ML was recorded in 2008. Streamflows steadily declined between 2004 and 2008 before a slight recovery in 2009. The large streamflow event in 2010 was followed by another below average year of 86 ML in 2011. The low annual streamflows of Skillogalee Creek can in part be attributed to a smaller catchment area.

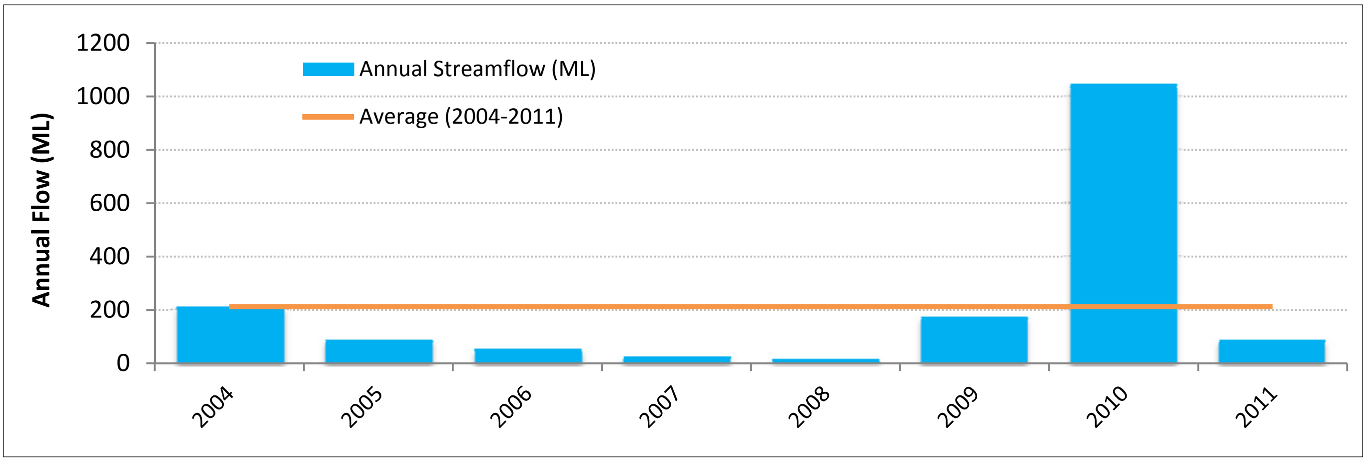


Figure 20. Annual streamflow record for Skillogalee Creek

Hill River has annual streamflow data for the period 1970-2011 with an average streamflow of 4104 ML (Figure 21). Larger streamflow events to occur during the period include 14570 ML in 1974, around 16500 ML in 1980 and 1981 and 20100 ML in 1992. The lowest streamflow recorded was 17 ML in 1977. The four years 1978-1981 show consecutive years of well above average streamflow. Hill River was recorded as having no streamflow in the years 1994, 2006 and 2008. The year 2009 is also recorded as having no streamflow, but had 41 days of missing data during the winter months, so some flows may be experienced but not recorded. From 2002 to 2009, Hill River experienced well below long term average streamflows, with the average across this period being 1640 ML. Streamflow returned in 2010 with 12100 ML recorded for the year.

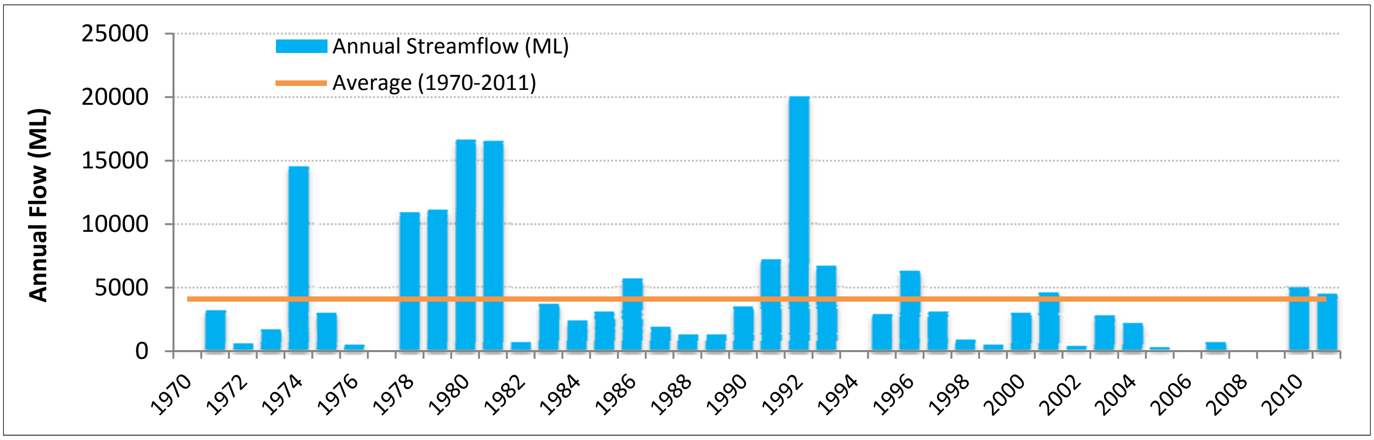


Figure 21. Annual streamflow record for Hill River

Hutt River has annual streamflow data for 1970-2011 with an average streamflow of 5944 ML (Figure 22). Some of the larger streamflow years to occur include 21690 ML in 1974, 28380 ML in 1978 and 29450 ML in 1992. The lowest recorded streamflow of 74 ML was in 2006. The pattern of wetter-than-average and drier-than-average streamflow years is similar to Hill River, as geographically, they are located close together. The year 2008 is recorded as having no streamflow, but all winter months had missing data, so this may not have been the case. From 1997 to 2009, Hutt River experienced well below average streamflows, with the average from 2002-09 being only 650 ML. Streamflow returned in 2010 with 7990 ML recorded followed by another below average year in 2011 with 5076 ML. The annual streamflow for Hutt River has only exceeded the long term average streamflow once in the past 15 years.

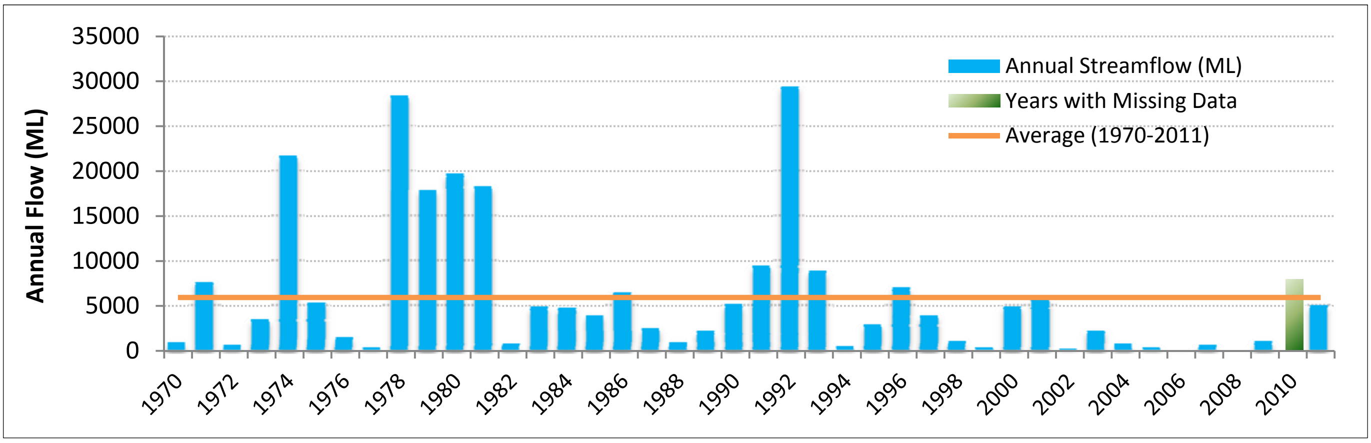


Figure 22. Annual streamflow record for Hutt River

Broughton River has annual streamflow data from 1972-2011 with an average streamflow of 26087 ML (Figure 23). Some of the larger streamflow years to occur for Broughton River include 78860 ML in 1981, 94270 ML in 1974 and 112400 ML in 1992. The lowest annual streamflow of 4259 ML was recorded in 1977. The first 21 years of the data record between 1972 and 1992 has an average streamflow of 34650 ML, considerably higher than the next 19 years of data between 1993 and 2011, which has an average of 16620 ML. The annual streamflow for Broughton River has only exceeded the long term average streamflow twice in the past 15 years.

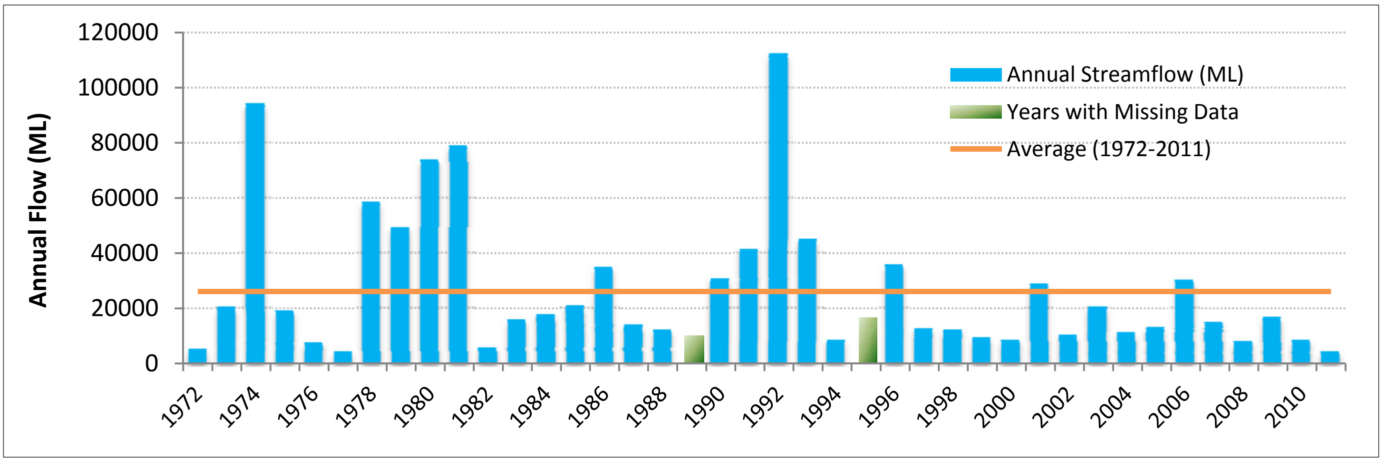


Figure 23. Annual streamflow record for the Broughton River

Rocky River D/S Threadgolds Crossing is a relatively new station with annual streamflow data for 2004-11. The average streamflow during this period was 495 ML (Figure 24). Years 2004, 2005 and 2008 recorded well below average streamflows, with 2009 and 2010 recording well above average streamflows. The highest annual streamflow of 898 ML was recorded in 2009 and the lowest of 140 ML was recorded in 2004. The depth of runoff is only 0.4mm, which is considered quite low and much lower than for the other monitoring sites.

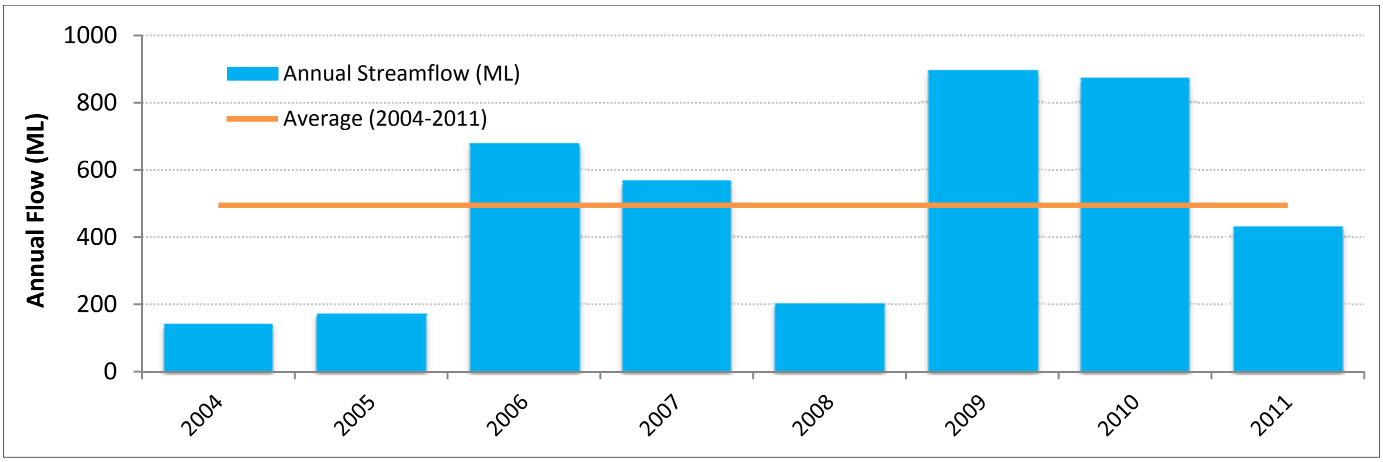


Figure 24. Annual streamflow record for Rocky River

Kanyaka Creek has annual streamflow data for 1978-2011 with an average streamflow of 610 ML (Figure 25). The high streamflow year of 1989 produced 4454 ML while the low of 29 ML was recorded in 1999. Throughout the data record there have been 13 years that have produced less than 100 ML of streamflow.

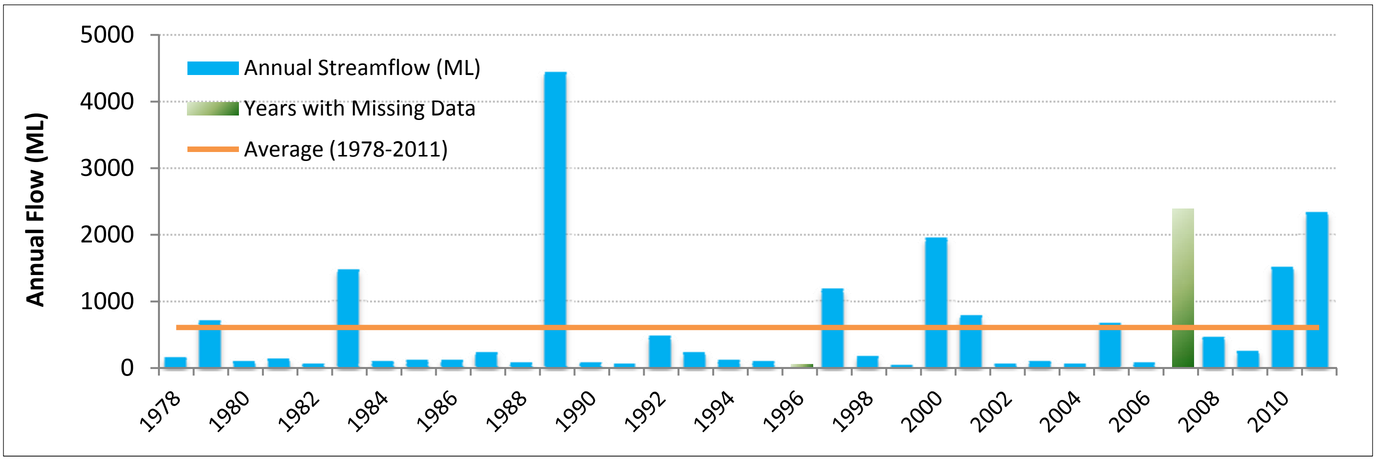


Figure 25. Annual streamflow record for Kanyaka Creek

Spring Creek has streamflow data for 2004-11 with an average annual streamflow of 880 ML over this period (Figure 26). This average is possibly distorted by the very high runoff year of 2010. The largest streamflow on record for Spring Creek is 3333 ML in 2010 and the lowest being 10 ML in 2007, but 2007 had significant winter days with missing data. From 2004 to 2007, Spring Creek experienced well below average streamflows. Higher annual streamflows were recorded between 2009 and 2010 but were followed by another below average year in 2011.

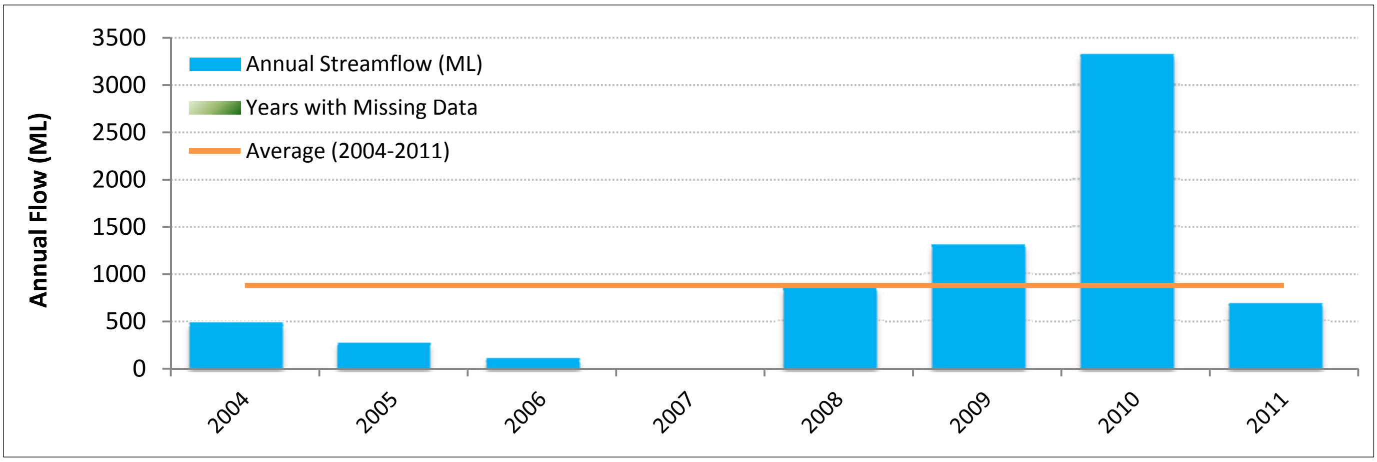


Figure 26. Annual streamflow record for Spring Creek

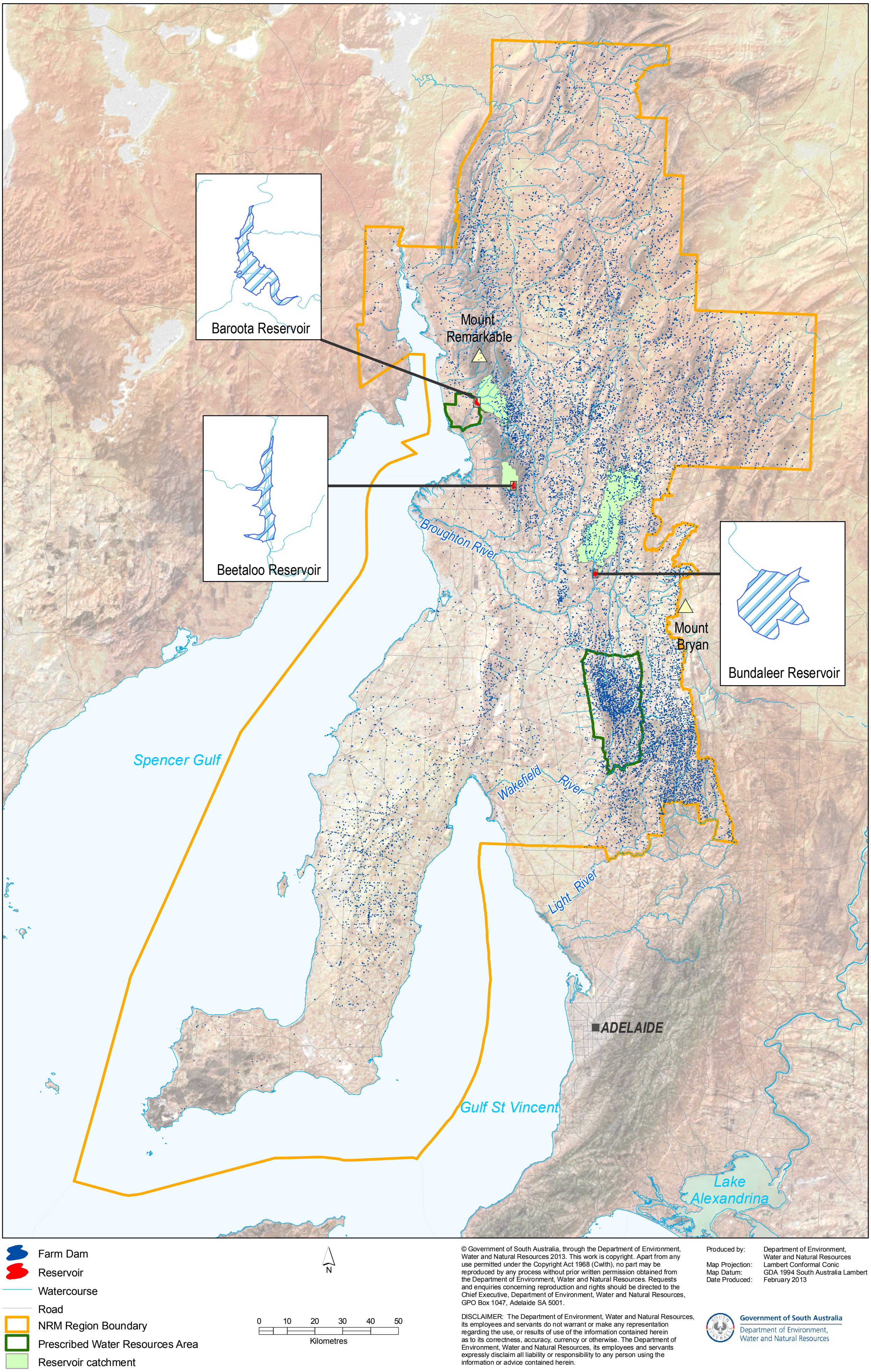
3.3. Surface water storage

Surface water storage in the region consists of farm dams and public reservoir storages. A report by Deane and Graves (2008) estimates the number of farm dams in the Wakefield, Broughton, Light and Willochra catchments to be around 8800, with an estimated combined storage volume of 22 000 ML. Baroota Reservoir, Beetaloo Reservoir and Bundaleer Reservoir are the three reservoirs within the NRM region boundary. All are located in the central part of the region (Figure 27). Baroota and Bundaleer Reservoirs have similar storage capacity at 6140 ML and 6370 ML respectively, with Beetaloo approximately half the other's capacity at 3180 ML. Construction of Baroota Reservoir was completed in 1921, Beetaloo Reservoir completed in 1890, while Bundaleer Reservoir was completed in 1903.

Water level data were collected at the Baroota Reservoir (A5080500) between 1978 and 2010. In that time only six events caused the reservoir to reach the spill height of 23 m. The reservoir was used as a balancing storage for the reticulation of River Murray pipeline water up until 1997, but has since been removed from the distribution network by SA Water due to water quality issues. Leakage from the reservoir is known to contribute to groundwater recharge downstream, as well as short periods of intensive recharge when the reservoir spills.

Beetaloo Reservoir (A5070502) had water level data recorded between 1980 and 2008. Water levels fell below the minimum water-recording level of 6.5 m twice in June 1981 and between June 1982 and March 1983. The reservoir was completely dry between August and December 1982. Water level data are not available for Bundaleer Reservoir.

The permanent waterholes in the region are considered to be groundwater dependent, particularly in summer when the streams cease to flow (NYNRMB 2009a). Deane *et al.* (2005) has however outlined that these permanent pools are beginning to dry out for the first time since European settlement.



Produced by: Department of Environment, Water and Natural Resources
Map Projection: Lambert Conformal Conic
Map Datum: GDA 1994 South Australia Lambert
Date Produced: February 2013

Figure 27. Reservoirs and farm dams in the Northern and Yorke NRM Region

4. Investment opportunities

This report has collated surface water information for the Northern and Yorke NRM region and presents a regional description of the non-prescribed surface water resources. Hydrological data have been compiled with particular attention given to the major surface water catchments in the region.

In preparing this report, a number of opportunities have been identified to enhance surface water knowledge and data in the region, to inform decisions by water resource managers. These opportunities are detailed below to inform future investment planning:

1. Effective water management relies on a solid knowledge base, so ensuring monitoring infrastructure is maintained for the long-term and to appropriate standards is important. Maintaining current monitoring stations to the State Water Monitoring Operational Framework will enable ongoing surveillance of surface water resources in the region and assist in water management and planning decisions. Continuous and long term data are important to calibrate and validate hydrological models used to inform decision making.

2. Currently there are no streamflow or salinity monitoring stations in the Baroota PWRA. Installation of a streamflow and water quality monitoring station in Baroota Creek would facilitate improved reporting on the status and condition of the PWRA.

3. Groundwater-sustaining permanent pools and watercourses recharging groundwater aquifers are highly significant in some areas. However, interaction between surface water and groundwater in the region is not well understood. Opportunities exist to better understand the scale and processes of surface water – groundwater interaction in non-prescribed areas of the region, which would assist in determining resource capacity, sustainable rates of extraction of water resources and sustaining water supply over a given time period. Streamflow monitoring in the lower reaches of major catchments would assist in understanding the complex surface water – groundwater interactions as water flows from the hills to the terminal points, be these lakes or the sea. Many streams in the region are losing in their lower reaches.

4. Evaporation monitoring is limited to three stations in the region. Establishment and maintenance of evaporation stations in the north of the region and on lower Yorke Peninsula would improve the network's coverage of climate variation in the region and therefore support more robust water resource assessments in the region.

5. Summary

Some of the challenges associated with managing the State's natural resources include the increasing demand for resources, climate change impacts and making well-informed decisions with existing data. It is important to ensure access to sufficient and reliable fit-for-purpose water that can be used to support food and wine production, mining expansion, liveability in our towns and cities and the health of the environment.

Water resources are essential in maintaining the social fabric and economic viability of the region. This includes the importance of sustaining agriculture, industry, mining and rural townships. Many townships and homesteads rely heavily on imported water and groundwater for stock and domestic water supplies. In response, it has become necessary to improve the knowledge of water resources to improve resource management. The objective of this project is to improve the understanding of non-prescribed surface water resources in the region, as they are traditionally poorly understood, due to limited monitoring and investigation programs. The assessments in this report have collated existing data on climate and surface water hydrology to consolidate current knowledge of the Northern and Yorke NRM Region.

Climate change projections indicate a reduction in rainfall and increase in temperature for the region. Based on climate change projections for the Clare Valley PWRA and the Baroota PWRA, reduction in rainfall is predicted to reduce runoff in these areas at a range of scales, directly influencing the users of water resources. At the regional scale, the drivers of increasing water demand include population growth, livestock numbers, mining activity and tourism.

The rainfall monitoring network in the most of the region provides good representation of the distribution of daily rainfall across the region. Some 160 rainfall monitoring stations are active across the region and approximately half had long term data of more than 100 years. However, the lower Yorke Peninsula and the far north of the region could benefit from additional rainfall monitoring and evaporation data are limited to three active stations across the region. Major streams generate flow from the northern Mount Lofty Ranges and Southern Flinders Ranges. This is where streamflow monitoring is currently focused (nine active streamflow monitoring stations), limited to the four main surface water catchments of the region.

This report has collated existing climate and surface water hydrology data, which has led to the identifications of opportunities to improve current knowledge. These opportunities include augmentation of monitoring and improved knowledge regarding the interaction of surface water and groundwater. As such, this report will support water planning and management decision making in the Northern and Yorke NRM Region.

Units of measurement

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	µg	10^{-6} g	mass
microlitre	µL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	365 or 366 days	time interval

Glossary

Act (the) — In this document, refers to the *Natural Resources Management (SA) Act 2004*, which supersedes the *Water Resources (SA) Act 1997*

Annual adjusted catchment yield — Annual catchment yield with the impact of dams removed

Aquatic ecosystem — The stream channel, lake or estuary bed, water and/or biotic communities and the habitat features that occur therein

Aquifer — An underground layer of rock or sediment that holds water

Arid lands — In South Australia, arid lands are usually considered to be areas with an average annual rainfall of less than 250 mm and support pastoral activities instead of broadacre cropping

Baseflow — The water in a stream that results from groundwater discharge to the stream; often maintains streamflows during seasonal dry periods and has important ecological functions

Basin — The area drained by a major river and its tributaries

Biodiversity — The number and variety of organisms found within a specified geographic region

BoM — Bureau of Meteorology, Australia

Catchment — That area of land determined by topographic features within which rainfall will contribute to run-off at a particular point

Dams, off-stream dam — A dam, wall or other structure that is not constructed across a watercourse or drainage path and is designed to hold water diverted or pumped from a watercourse, a drainage path, an aquifer or from another source; may capture a limited volume of surface water from the catchment above the dam

Dams, on-stream dam — A dam, wall or other structure placed or constructed on, in or across a watercourse or drainage path for the purpose of holding and storing the natural streamflow of that watercourse or the surface water

Dams, turkey nest dam — An off-stream dam that does not capture any surface water from the catchment above the dam

DEWNR — Department of Environment, Water and Natural Resources (Government of South Australia)

DFW — former Department for Water (Government of South Australia)

d/s — Downstream

DWLBC — former Department of Water, Land and Biodiversity Conservation (Government of South Australia)

Ecology — The study of the relationships between living organisms and their environment

Ecosystem — Any system in which there is an interdependence upon, and interaction between, living organisms and their immediate physical, chemical and biological environment

Environmental water requirements — The water regimes needed to sustain the ecological values of aquatic ecosystems, including their processes and biological diversity, at a low level of risk

EPA — Environment Protection Authority (Government of South Australia)

Ephemeral streams or wetlands — Those streams or wetlands that usually contain water only on an occasional basis after rainfall events. Many arid zone streams and wetlands are ephemeral.

Flow regime — The character of the timing and amount of streamflow in a stream

Groundwater — Water occurring naturally below ground level or water pumped, diverted and released into a well for storage underground

Hydrology — The study of the characteristics, occurrence, movement and utilisation of water on and below the Earth's surface and within its atmosphere

Irrigation — Watering land by any means for the purpose of growing plants

Lake — A natural lake, pond, lagoon, wetland or spring (whether modified or not) that includes part of a lake and a body of water declared by regulation to be a lake. A reference to a lake is a reference to the bed, banks and shores of the lake or the water for the time being held by the bed, banks and shores of the lake, or both, depending on the context.

Land — Whether under water or not, and includes an interest in land and any building or structure fixed to the land

m AHD — Defines elevation in metres (m) according to the Australian Height Datum (AHD)

Model — A conceptual or mathematical means of understanding elements of the real world that allows for predictions of outcomes given certain conditions. Examples include estimating catchment run-off, assessing the impacts of dams or predicting ecological response to environmental change

Natural resources — Soil, water and marine resources, geological features and landscapes, native vegetation, native animals and other native organisms and ecosystems

NRM — Natural Resources Management; caring for our natural resources – balancing people's needs with those of nature

NYNRM — Northern and Yorke Natural Resources Management (region)

Pasture — Grassland used for the production of grazing animals such as sheep and cattle

Perennial streams — Permanently inundated watercourses. These watercourses flow throughout the year except in years of infrequent drought.

Population — For the purposes of natural resources planning, the set of individuals of the same species that occurs within the natural resource of interest

Potable water — Water suitable for human consumption such as drinking or cooking water

Prescribed water resource — A water resource declared by the Governor to be prescribed under the Act. Prescription of a water resource requires that future management of the resource be regulated via a licensing system.

PWRA — Prescribed Water Resources Area, in accordance with the Act.

SA Water — South Australian Water Corporation (Government of South Australia)

Stock use — The taking of water to provide drinking water for stock other than stock subject to intensive farming (as defined by the Act)

Sub-catchment — The area of land determined by topographical features within which rainfall will contribute to run-off at a particular point. A number of sub-catchments form a catchment.

Surface water — (a) water flowing over land (except in a watercourse), (i) after having fallen as rain or hail or having precipitated in any another manner, (ii) or after rising to the surface naturally from underground; (b) water of the kind referred to in paragraph (a) that has been collected in a dam or reservoir

Tributary — A river or creek that flows into a larger river

u/s — Upstream

WAP — Water Allocation Plan; a plan prepared by a NRM Board or water resources planning committee and adopted by the Minister in accordance with the Act

Water body — Includes watercourses, riparian zones, floodplains, wetlands, estuaries, lakes and groundwater aquifers

Watercourse — A river, creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; a lake through which water streamflows; a channel (but not a channel declared by regulation to be excluded from the this definition) into which the water of a watercourse has been diverted; and part of a watercourse

Water dependent ecosystems — Those parts of the environment, the species composition and natural ecological processes, that are determined by the permanent or temporary presence of flowing or standing water, above or below ground; the in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries and lakes are all water-dependent ecosystems

Water plans — The State Water Plan, NRM plans, water allocation plans and local water management plans prepared under Part 7 of the Act

WDE — Water dependent ecosystem

Wetlands — Defined by the Act as a swamp or marsh and includes any land that is seasonally inundated with water. This definition encompasses a number of concepts that are more specifically described in the definition used in the Ramsar Convention on Wetlands of International Importance. This describes wetlands as areas of permanent or periodic to intermittent inundation, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tides does not exceed six metres.

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