# South Australian Gulf

# 8 South Australian Gulf

## 8.1 Introduction

This chapter examines water resources in the South Australian Gulf region in 2011–12 and over recent decades. It starts with summary information on the status of water flows, stores and use. This is followed by descriptive information for the region including the physiographic characteristics, soil types, population, land use and climate.

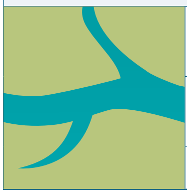
Spatial and temporal patterns in landscape water flows are presented as well as an examination of the surface and groundwater resources. The chapter concludes with a review of the water situation for urban centres and irrigation areas. The data sources and methods used in developing the diagrams and maps are listed in the Technical Supplement.

## 8.2 Key information

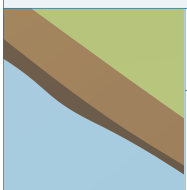
Table 8.1 gives an overview of the key components of the data and information in this chapter.

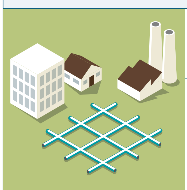
Table 8.1 Key information on water flows, stores and use in the South Australian Gulf region

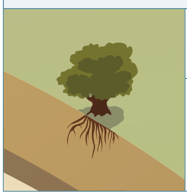
| Landscape water flows | | | |
|---|---|---|---|
| | Region average | Difference from 1911–2012 long-term annual mean | Decile ranking with respect to the 1911–2012 record |
| Rainfall | 331 mm | +10% | 8th—above average |
| Evapo-transpiration | 306 mm | +7% | 8th—above average |
| Landscape water yield | 9 mm | −10% | 6th—average |

| Streamflow (at selected gauges) | | |
|---|---|---|
|  | Annual total flow: | Highly variable pattern of high and low flow in the river gauges in the south eastern rivers |
| | Salinity: | Annual median electrical conductivity predominantly above 1,000 µS/cm in gauges in the south eastern rivers and on Kangaroo Island |
| | Flooding: | No major flooding in the monitoring gauges surrounding Adelaide |

| Surface water storage (comprising about 74% of the region's total capacity of all major storages) | | | | | | | |
|---|---|---|---|---|---|---|---|
|  | Total accessible capacity | 30 June 2012 | | 30 June 2011 | | Change | |
| | | accessible volume | % of total capacity | accessible volume | % of total capacity | accessible volume | % of total capacity |
| | 197 GL | 96 GL | 49% | 135 GL | 69% | −39 GL | −20% |

| Groundwater (in selected aquifers) | | |
|---|---|---|
|  | Levels: | Variable trends in the different aquifers, predominantly falling in middle aquifers and rising in deeper aquifers |
| | Salinity: | Saline groundwater (≥3,000 mg/L) throughout most of the region with non-saline (<3,000 mg/L) areas around Adelaide and in the Flinders Ranges |

| Urban water use (Adelaide) | | | | |
|---|---|---|---|---|
|  | Total sourced in 2011–12 | Total sourced in 2010–11 | Change | Restrictions |
| | 138 GL | 125 GL | +13 GL (+10%) | Water Wise Measures |

| Annual mean soil moisture (model estimates) | | |
|---|---|---|
|  | Spatial patterns: | Predominantly average annual mean soil moisture and very much above average soil moisture in the far north |
| | Temporal patterns in regional average: | Average to above average soil moisture throughout the year |

## 8.3 Description of the region

The South Australian Gulf region extends over 117,700 km$^2$ of South Australia, surrounding the Gulf of St Vincent and Spencer Gulf, and stretching inland 300 km to the north of Spencer Gulf. To the east (at the border of the Murray–Darling Basin) the region is bounded by the western slopes of the Mount Lofty and Flinders Ranges; to the north, it is bounded by the Lake Eyre Basin; and to the west by the South Western Plateau region. The south of the region includes Kangaroo Island.

Except for the Flinders Ranges (with a highest peak of 932 m) and the Mount Lofty Ranges, the region has moderately flat terrain. Subsections 8.3.1–8.3.4 give more detail on the physical characteristics of the region.

The South Australian Gulf region has a population in excess of 1.4 million, or just over 6% of the country's total population (Australian Bureau of Statistics [ABS] 2011b). Major population centres in the region include Adelaide, Victor Harbour, Port Pirie, Port Augusta, Whyalla and Port Lincoln (Figure 8.1). Further discussion of the region's population distribution and urban centres can be found in subsection 8.3.6 and section 8.6 respectively.

Dryland pasture and cropping are major land uses in the region. Grazing is concentrated in the northern arid river basins such as Lake Torrens, Willochra Creek and Mambray Coast (south of Lake Torrens), and the Broughton River basin. Several river basins (Wakefield, Gawler and Broughton) have 50% or more of their area occupied by dryland agriculture. More than half of the land area devoted to nature conservation is a single reserve covering the Lake Torrens salt lake (Figure 8.1).

Other significant areas of nature conservation occur on Eyre Peninsula, Kangaroo Island, and through the Mount Lofty and Flinders Ranges. Irrigated agriculture is mostly for viticulture and wine production, the most important of which is concentrated in the Onkaparinga catchment. Section 8.7 has more information on agricultural activities in the region.

The region has a Mediterranean climate in the southeast, and a semi-arid climate inland and to the north. Rainfall mainly occurs in winter. Spring and summer rainfall can be substantial although highly variable. Subsections 8.3.7 and 8.3.8 provide more information on the rainfall patterns and deficits across the region.

There are no major permanent freshwater lakes in the South Australian Gulf region. A number of large endorheic salt lakes exist in the north, including Lake Torrens, Island Lagoon, Pernatty Lagoon, Lake Hart, Lake Gilles and Lake MacFarlane (Figure 8.1). In the south, short rivers drain into the ocean. The region has some important coastal and marine ecosystems.

The hydrogeology of the region can be partitioned into areas of surficial and underlying sediments, and areas of outcropping fractured rock. Significant groundwater resources are found in surficial sediments and the Quaternary and Tertiary aquifers that underlie them. Typically fractured rock systems offer restricted low volume groundwater resources; however, there are some parts of this region with a greater density of fractures and more substantial groundwater resource availability. A more detailed description of the rivers and groundwater status is given in section 8.5.

A view of rural Southern Australia looking north towards Flinders Range | Malcolm Watson


Figure 8.1 Major rivers and urban centres in the South Australian Gulf region

## 8.3.1 Physiographic characteristics

The physiographic map in Figure 8.2 shows areas with similar landform evolutionary histories (Pain et al. 2011). These can be related back to similar geology and climatic impacts which define the extent of erosion processes. The areas have distinct physical characteristics that can influence hydrological processes. The South Australian Gulf region has two physiographic provinces, namely Eyre Peninsula and Gulfs Ranges.

The Eyre Peninsula province occupies 43% of the region and has alluvial plains and salt lakes with some dunes in the north. Moving south, this changes to rounded ranges of acid volcanic rocks and hills of metamorphic rocks followed by stable northwest–southeast oriented longitudinal dunes, locally broken by granite hills, ridges of metamorphic rocks and plains extending as headlands and inlets along the southern coast.

The Gulfs Ranges province occupies 57% of the region and has a complex fold belt of prominent ranges in the north, chiefly quartzite with vales on weaker rocks, and in the southeast stepped fault blocks and islands, mainly of weathered metamorphic rocks with ferruginous cappings. In the northwest, there are dissected sandstone plateaus, salt lakes, alluvial and littoral plains and stabilised longitudinal dunes. In the southwest are undulating lowlands of folded crystalline and metamorphic rocks covered by calcrete and stabilised northwest–southeast longitudinal dunes.

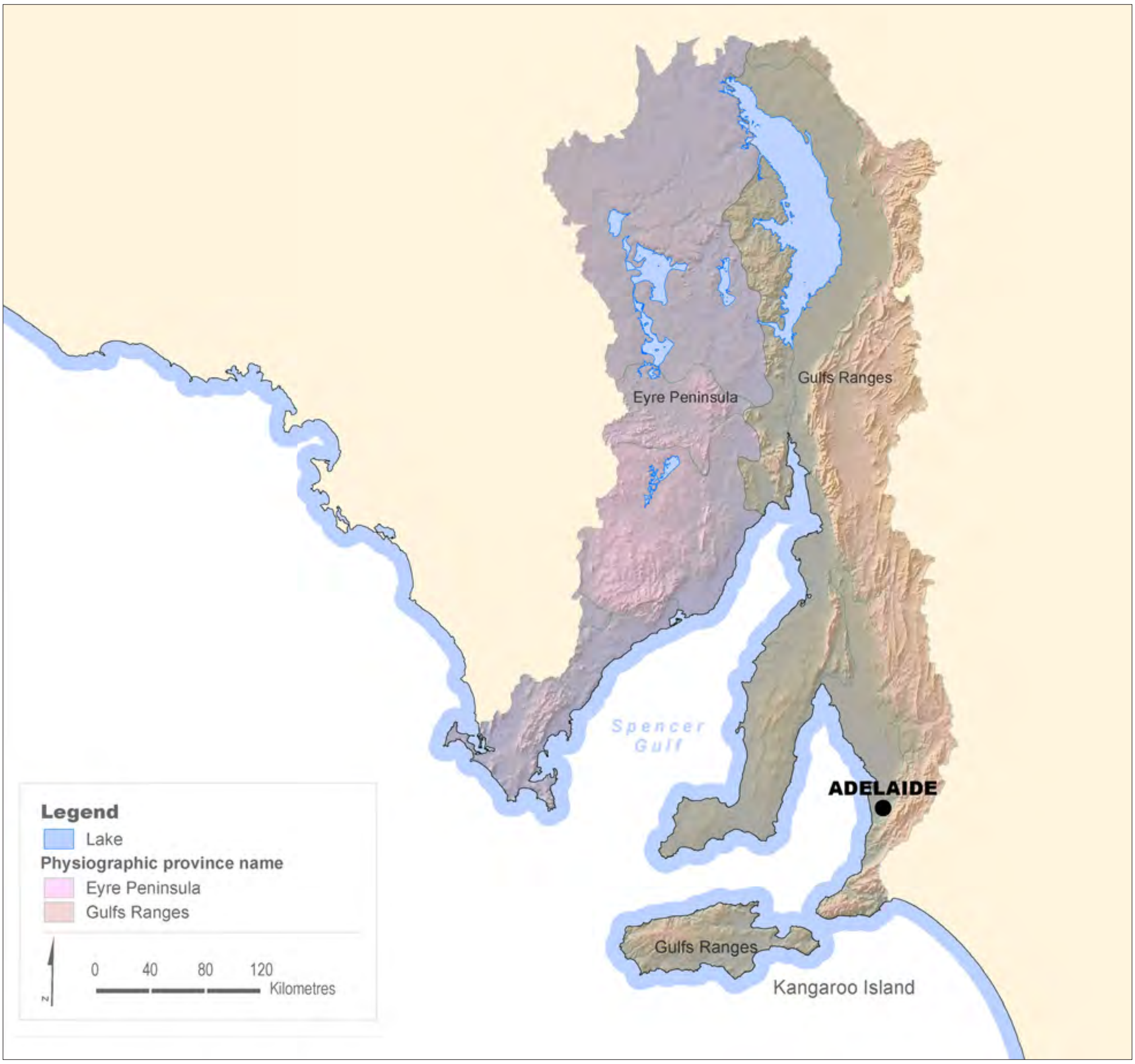



Figure 8.2 Physiographic provinces in the South Australian Gulf region

## 8.3.2 Elevation

Figure 8.3 presents ground surface elevations in the South Australian Gulf region. Information was obtained from the Geoscience website (www.ga.gov.au/topographic-mapping/digital-elevation-data.html). The region is clearly defined by the crest of the Mount Lofty Ranges in the south and the eastern ridges of the Flinders Ranges in the north. The highest point in this area is 932 m with most of the borderline on altitudes exceeding 400 m. To the north and the west of the region, the effective water divide is less obvious.

The major mountains in the west are the Minbrie Range on Eyre Peninsula, which reach altitudes of over 400 m above sea level. The western areas contain many closed drainage areas which do not drain towards the sea. This includes the large Lake Torrens basin, which covers the majority of the north of the region.

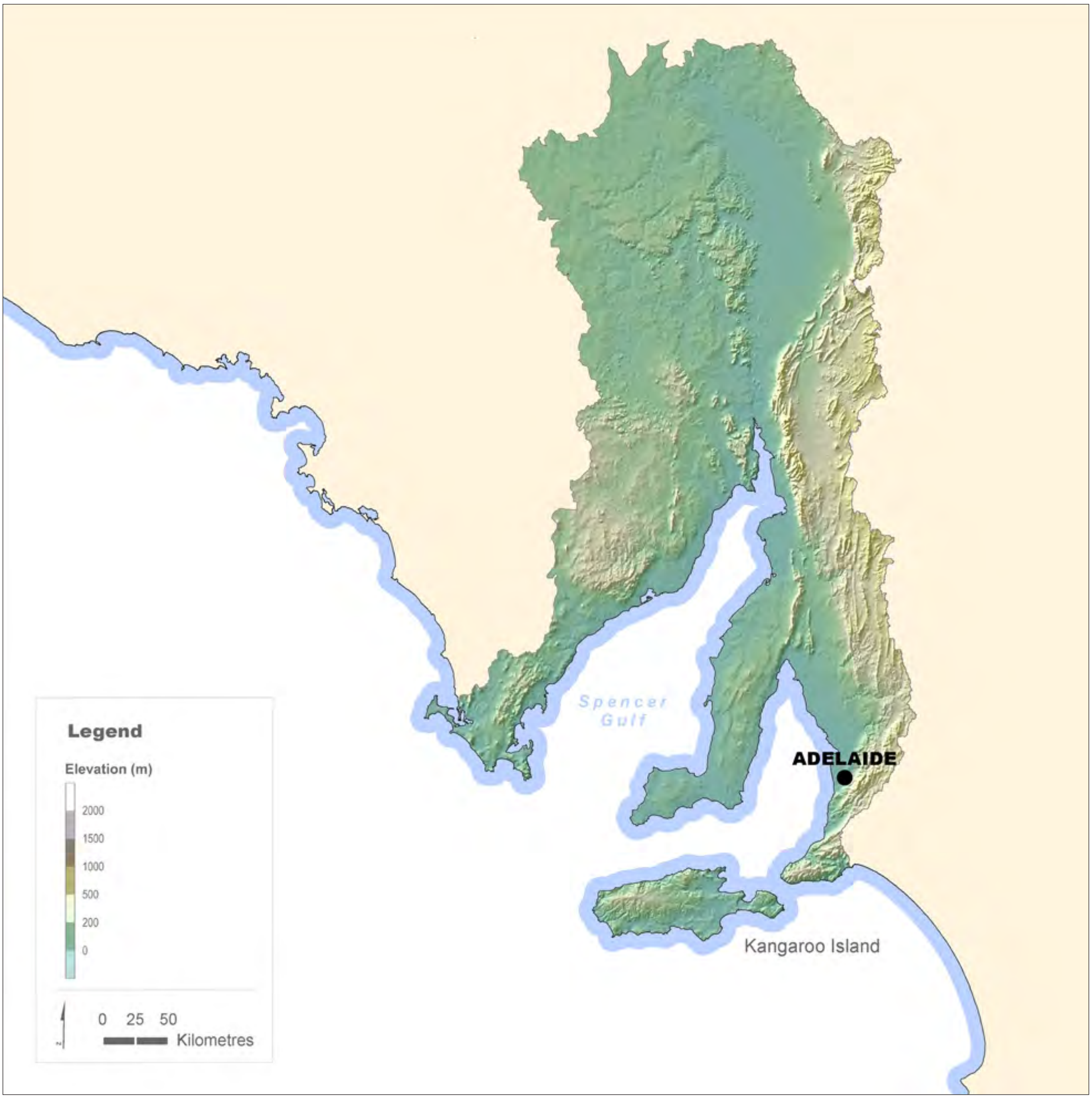



Figure 8.3 Ground surface elevations in the South Australian Gulf region

### 8.3.3 Slopes

Areas with steep slopes provide higher run-off generating potential than flat areas. The South Australian Gulf region has only some areas with steep slopes. Most of the area is rather flat (Table 8.2). The steep slopes in the map of Figure 8.4, in particular, highlight the Flinders Ranges in the east.

Table 8.2 Proportions of slope classes for the region

| Slope class (%) | 0–0.5 | 0.5–1 | 1–5 | > 5 |
|---|---|---|---|---|
| Proportion of region (%) | 31.4 | 19.8 | 39.8 | 9.0 |

Significant slopes also exist southeast of Adelaide. The slopes were derived from the elevation information used in the previous section.

The region has a number of flat coastal plains, which, in combination with the climate and the appropriate soil conditions, have formed ideal solar salt production sites.

The flat plains in the north are mostly salt lakes, which collect the sparse run-off from their surrounding ranges. The large flat plain in the centre-north is Lake Torrens, which has only filled once in the last 150 years, as generally it is a large salty flatland.

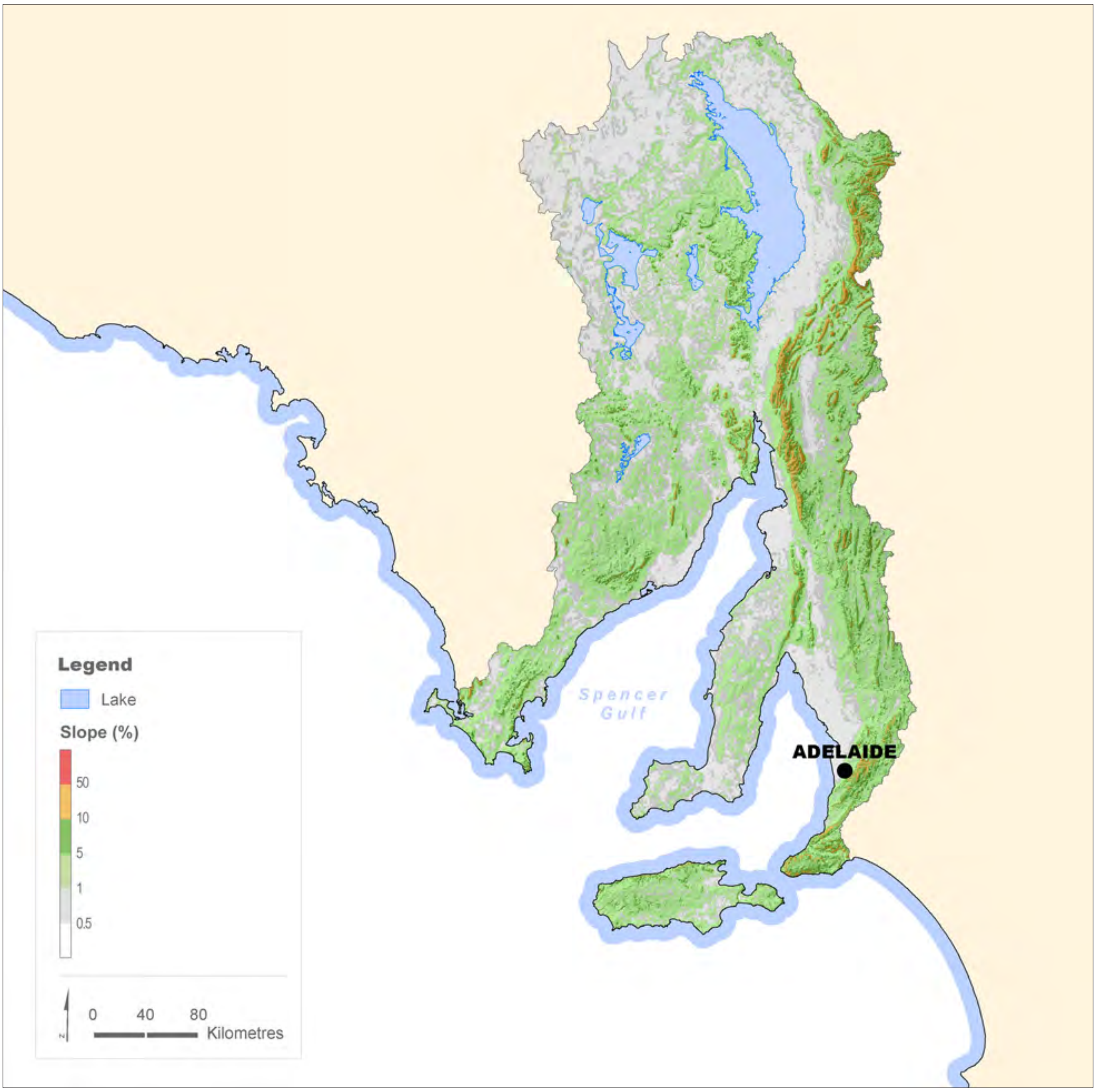



Figure 8.4 Surface slopes in the South Australian Gulf region

## 8.3.4 Soil types

Soils play an important role in the hydrological cycle by distributing water that reaches the ground. Water can be transported to rivers and lakes via the soil surface as run-off or enter the soil and provide water for plant growth as well as contribute to groundwater recharge. The nature of these hydrological pathways and the suitability of the soils for agricultural purposes are influenced by soil types and their characteristics. Soil type information was obtained from the Australian Soil Resource Information System website (www.asris.csiro.au).

About 88% of the South Australian Gulf region consists of four soil types, namely calcarosols, sodosols, chromosols and tenosols (Figure 8.5 and Figure 8.6).

Calcarosols are widely distributed across the region and cover about 45% of the total area. They are mainly present in areas used for pastures and to some extent for dryland agriculture. Calcarosols are characterised by a high content of calcium carbonate which occurs as soft or hard white fragments or as solid layers. These soils are often shallow and have a low water-holding capacity. They have a low to moderate agricultural potential, and salinity, alkalinity and boron toxicity may often cause problems.

Sodosols are common soils in the north and southwest and are scattered around in the southeast of the region. These soils have a strongly contrasting texture, with impermeable sodic subsoils arising from elevated sodium concentrations and clay. They are susceptible to dryland salinity as well as erosion if vegetation is removed.

Chromosols also have strongly contrasting texture, but have permeable subsoils which are not strongly acidic. They are dominant in the southeast of the region as well as on Kangaroo Island and are mostly present in pastures and areas used for dryland agriculture.

Tenosols are soils with minimal development throughout the profile. They show little or no change in texture and colour. They are often shallow or stony. These soils are low in chemical fertility and water-holding capacity and thus their agricultural potential is low. Tenosols are scattered in the central-west and in the south of the region and are mostly present in pastures and areas used for nature conservation.

The other soil types that have minimal representation in the South Australian Gulf region are rudosols, dermosol, ferrosols, hydrosols, kurosols and podosols (1–6% of the total area).

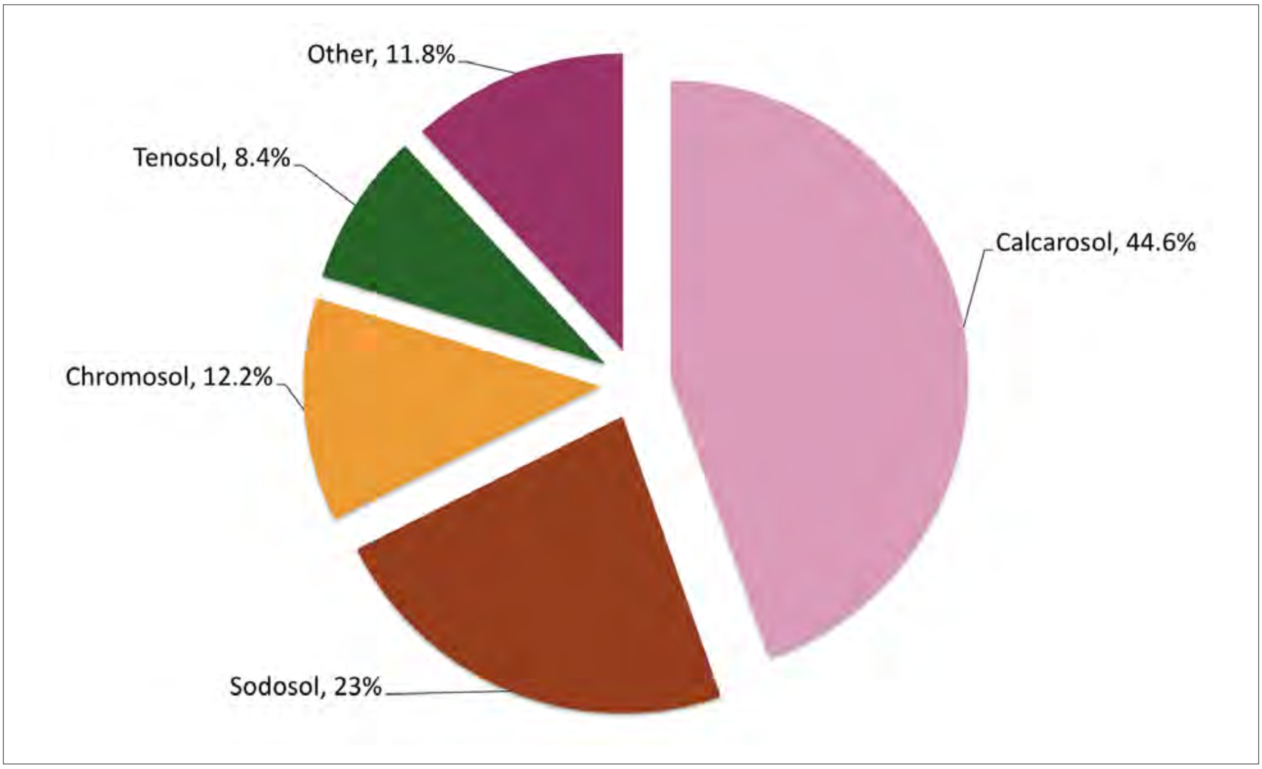



Figure 8.5 Soil types in the South Australian Gulf region

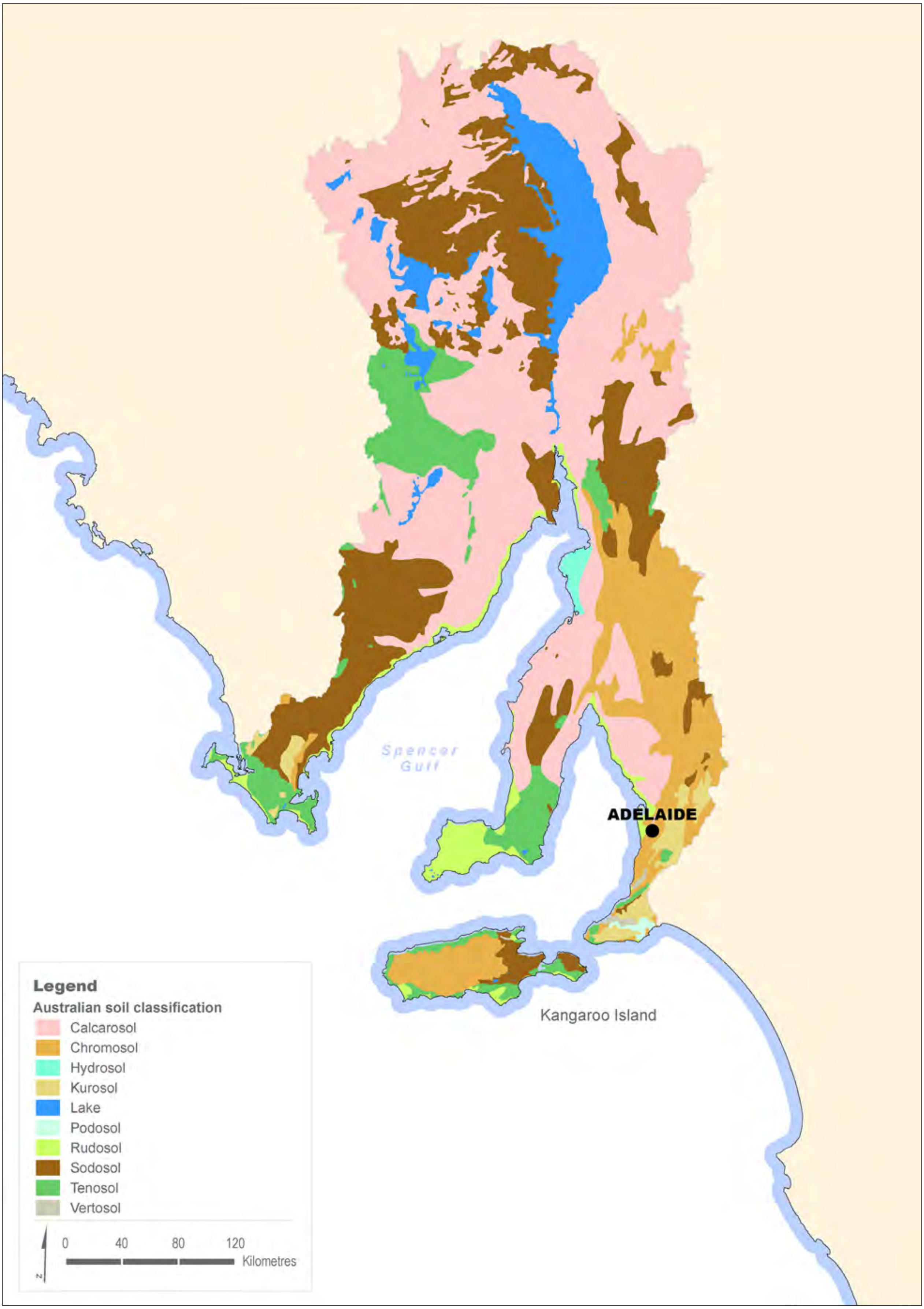



Figure 8.6 Soil type distribution in the South Australian Gulf region

### 8.3.5 Land use

Dryland pasture and cropping are major land uses in the region (Figure 8.7), being often combined to varying degrees in farming operations across the region (data from data.daff.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml). Grazing predominates in the northern arid river basins such as Lake Torrens, Willochra Creek and Mambray Coast (south of Lake Torrens), and the northern parts of the Broughton River basin. Several river basins (Wakefield, Gawler and Broughton) have 50% or more of their area occupied by dryland agriculture (Figure 8.7).

More than half of the land area devoted to nature conservation is a single reserve covering the Lake Torrens salt lake. Other significant areas of nature conservation occur on Eyre Peninsula, Kangaroo Island and in the Broughton River basin (Figure 8.8), and through the Mount Lofty and Flinders Ranges.

Irrigated agriculture is mostly for viticulture and wine production, the most important of which is concentrated in the Onkaparinga catchment.

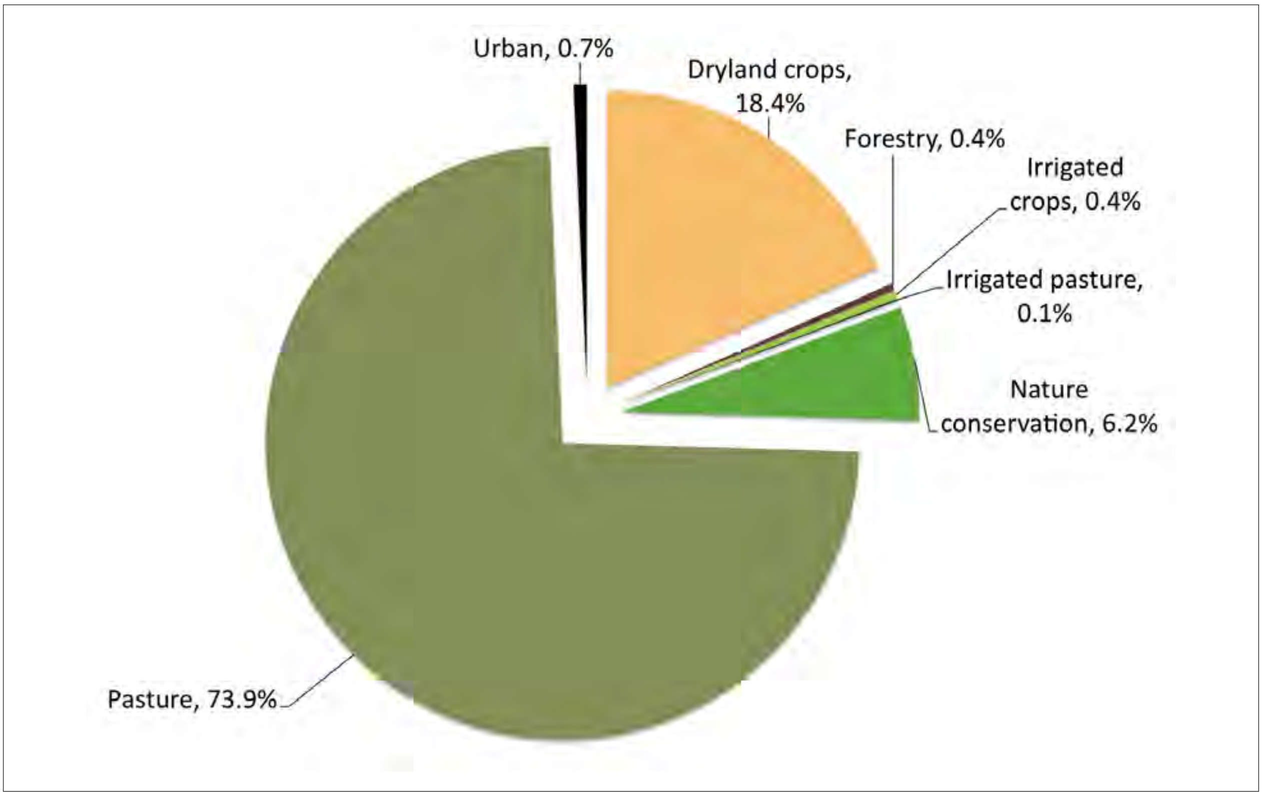



Figure 8.7 Land use in the South Australia Gulf region

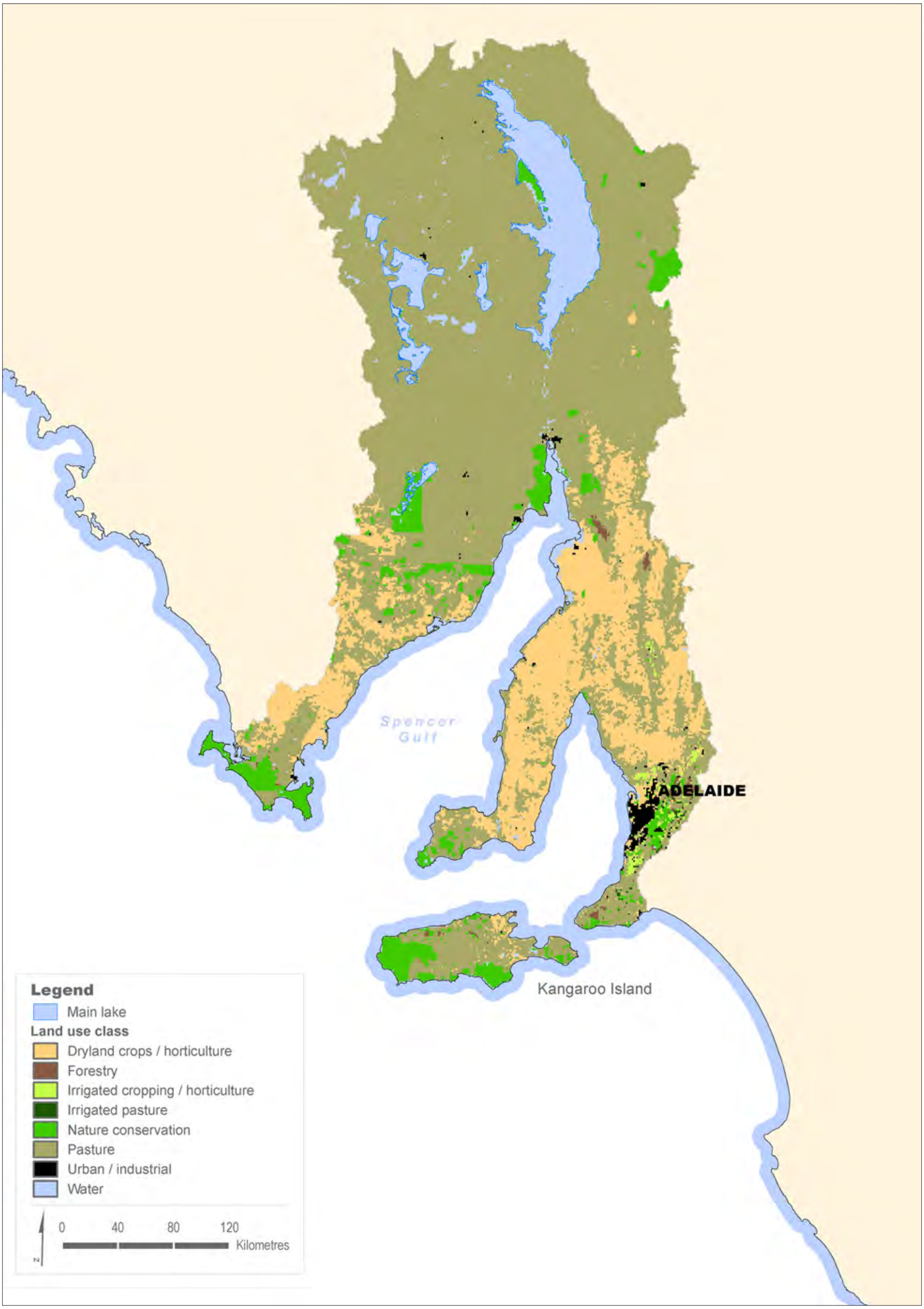



Figure 8.8 Land use distribution in the South Australian Gulf region

## 8.3.6 Population distribution

The South Australian Gulf region has a population of greater than 1.4 million. Approximately 88% of the population is concentrated in greater Adelaide which occupies the coastal plains along the eastern edge of the Gulf of St Vincent and extends up into the Adelaide Hills (Figure 8.9).

A number of smaller coastal cities and towns are distributed along the edge of the Spencer Gulf and are driven by mining, agriculture and fisheries.

Beyond these smaller centres the remaining population is sparsely distributed throughout the western and northern parts of the region. A number of remote Indigenous communities can be found scatted throughout these parts.

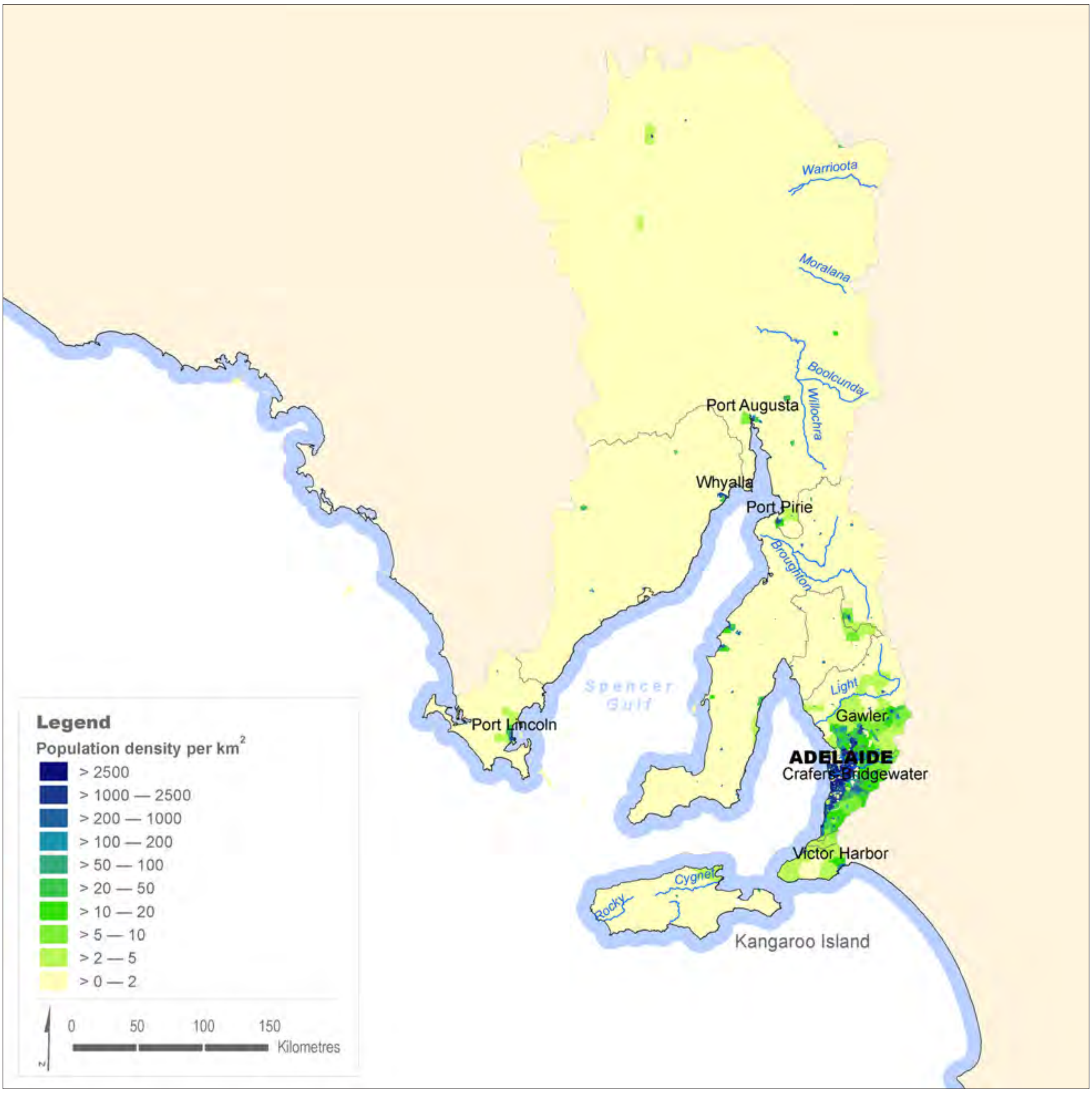



Figure 8.9 Population density and distribution in the South Australian Gulf region

### 8.3.7 Rainfall zones

The region has a Mediterranean climate in the southeast and a semi-arid climate to the north. Rainfall mainly occurs in winter, though highly variable contributor to rainfall in spring through to early autumn. Median rainfall varies strongly across the region, not exceeding 800 mm throughout (Figure 8.10).

In the most northern part of the region average annual rainfall is limited to less than 200 mm.

Moving south, the annual rainfall totals increase up to levels reaching over 600 mm in the southern tip of Eyre Peninsula and Kangaroo Island.

For more information on this and other climate classifications, visit the Bureau of Meteorology's (the Bureau's) climate website: www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp

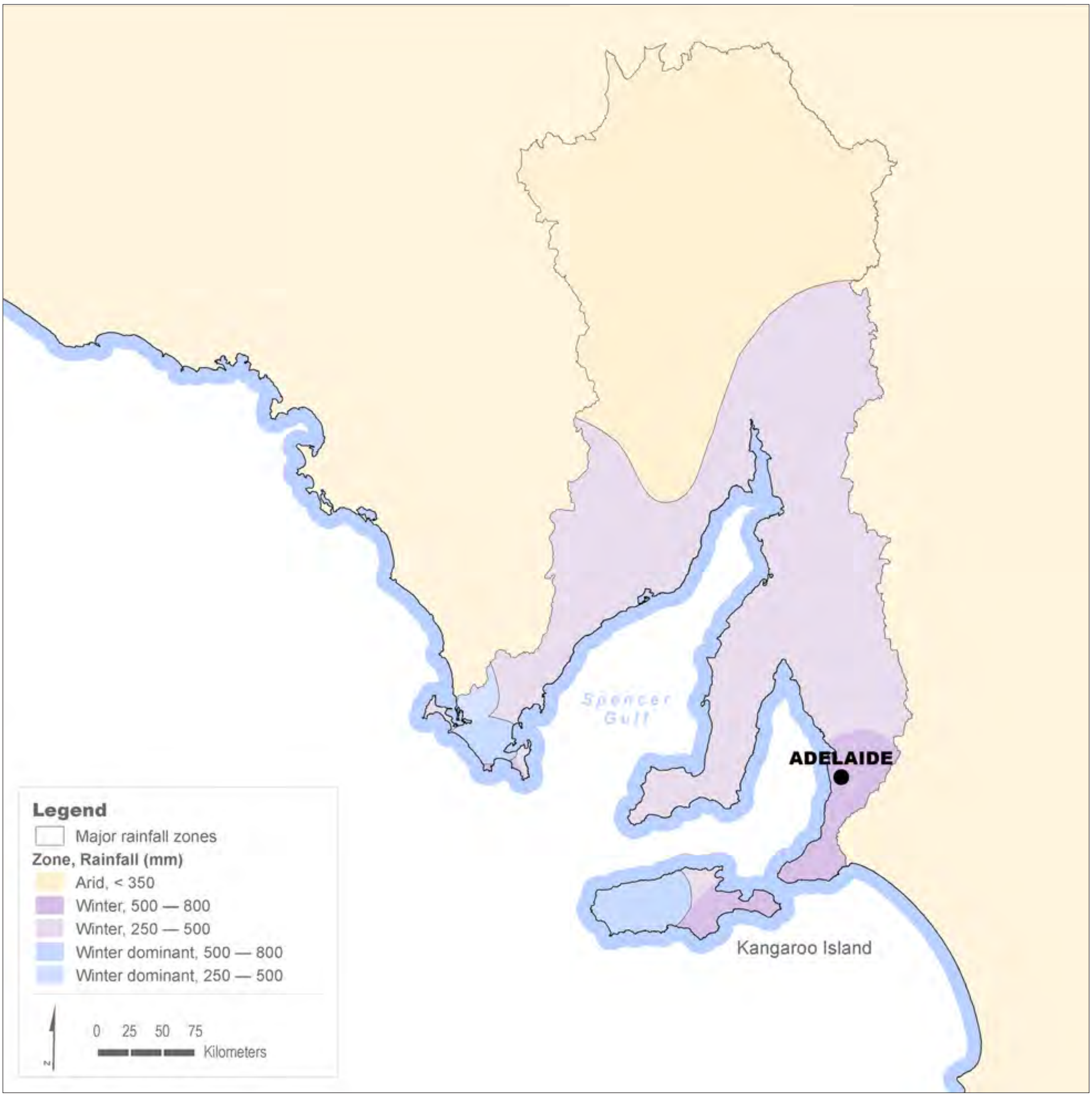



Figure 8.10 Rainfall zones in the South Australian Gulf region

## 8.3.8 Rainfall deficit

The rainfall deficit indicator, that is, rainfall minus potential evapotranspiration, gives a general impression about which parts of the region are likely to experience moisture deficits over the period of a year. The South Australian Gulf region has a general pattern of substantial deficits in relation to this indicator (Figure 8.11).

High deficits can be expected in large parts of the northern inland areas, which include a number of ephemeral lakes. These are lakes which only get filled after major rainfall. No land cover other than grasses and shrubs is present, resulting in low density stock farming.

In the south of the region, dryland cropping and pasture for livestock are major forms of land use. The farms strongly rely on April–October rainfall for their growing season.

The city of Adelaide has some surface water storages to support the supply of water, but the general deficit in this area means the city relies on water transferred from the River Murray, particularly in summer, and since October 2011 from desalinated water.

For more information on the rainfall and evapotranspiration data, see the Bureau's maps of average conditions: www.bom.gov.au/climate/averages/maps.shtml

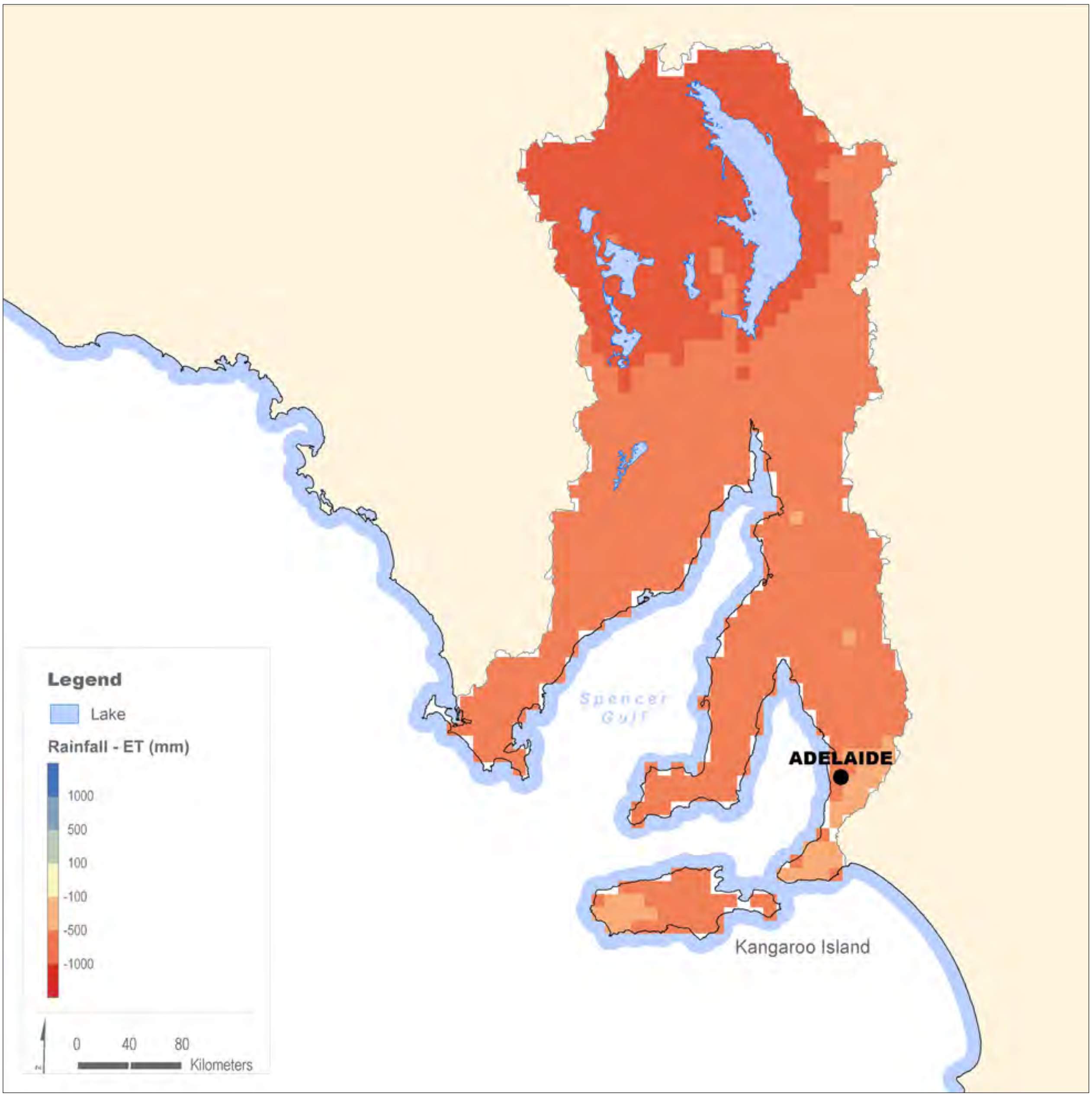



Figure 8.11 Rainfall deficit distribution in the South Australian Gulf region

## 8.4 Landscape water flows

This section presents analyses of the spatial and temporal variation of landscape water flows (rainfall, evapotranspiration and landscape water yield) across the South Australian Gulf region in 2011–12. National rainfall grids were generated using data from a network of persistent, high-quality rainfall stations managed by the Bureau. Evapotranspiration and landscape water yields were derived using the landscape water balance component of the Australian Water Resources Assessment System (Van Dijk 2010). These methods and associated output uncertainties are discussed in the Introduction and addressed in more detail in the Technical Supplement.

Figure 8.12 shows that the region has a seasonal rainfall pattern with a predominantly wetter winter and drier summer period. Evapotranspiration generally exceeds rainfall from spring up to early summer, extracting the excess water from the soils. The soils refill again in the wetter May–July period. The monthly landscape water yield history for the region shows a stable pattern of very low yield throughout the year.

The 2011–12 year was a relatively average year. Rainfall only exceeded the 90th percentile in the normally driest month of March, albeit only marginally.

Similar to rainfall, evapotranspiration was the highest in March. The rainfall of February and March contributed to higher than usual soil moisture, which in turn was available again for evapotranspiration. Evapotranspiration for March was third highest on record for the 1911–2012 period.

The landscape water yield for 2011–12 followed the very narrow bounds of the historic pattern. A marginally higher landscape water yield was found for March, although with no excessive volumes in absolute terms.

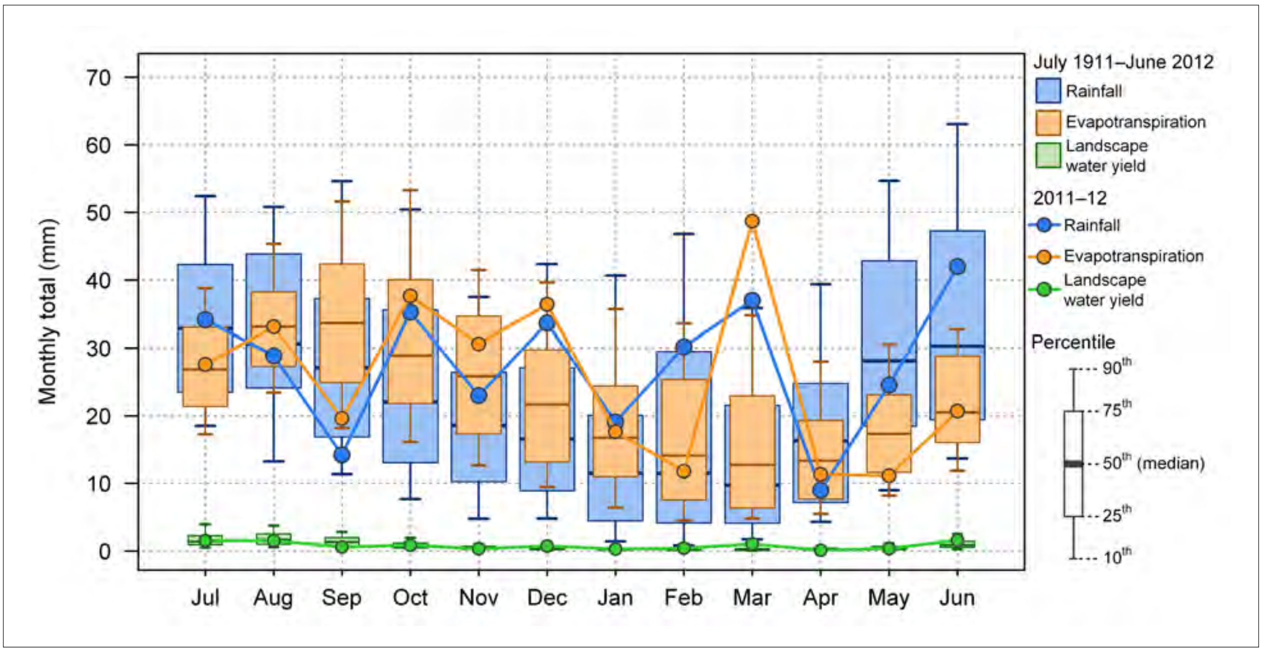



Figure 8.12 Landscape water flows in 2011–12 compared with the long-term record (July 1911–June 2012) for the South Australian Gulf region

### 8.4.1 Rainfall

Rainfall for the South Australian Gulf region for 2011–12 is estimated to be 331 mm. This is 10% above the region's long-term average (July 1911–June 2012) of 300 mm. Figure 8.13a shows that the highest rainfall occurred along the southern coastal areas with annual totals locally exceeding 600 mm for 2011–12. The majority of the north had rainfall not exceeding 300 mm, except for the slopes of the Flinders Ranges in the east.

Rainfall deciles for 2011–12 indicate average to above average rainfall for the entire region over the course of the year (Figure 8.13b). The wetter south of the region experienced predominantly average rainfall with the exception of the far southern corner of Eyre Peninsula. In the centre and far north of the region, large areas of above average rainfall are present. As these areas are generally identified as arid, the above average areas experienced no substantially higher absolute total annual rainfall.

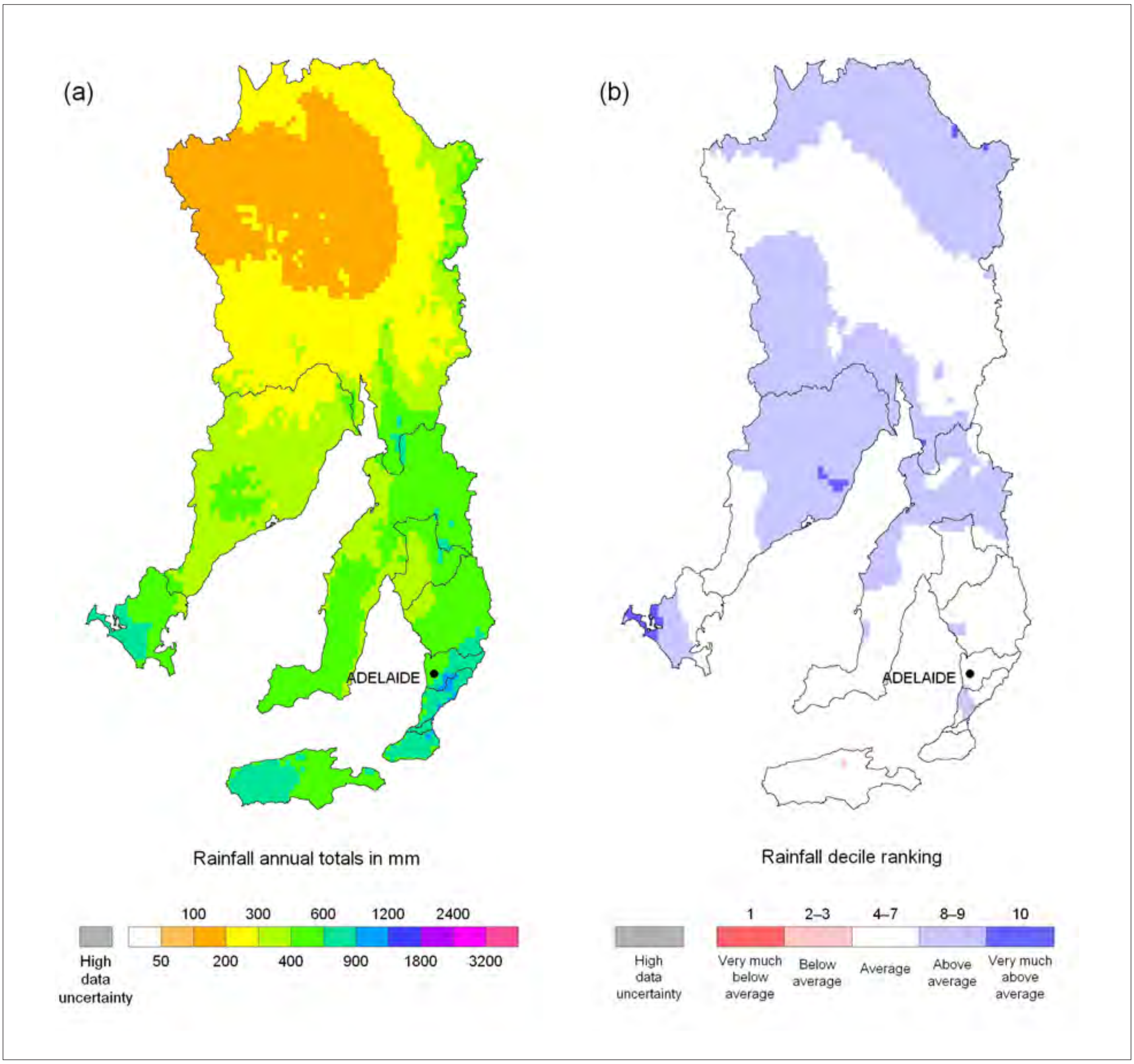
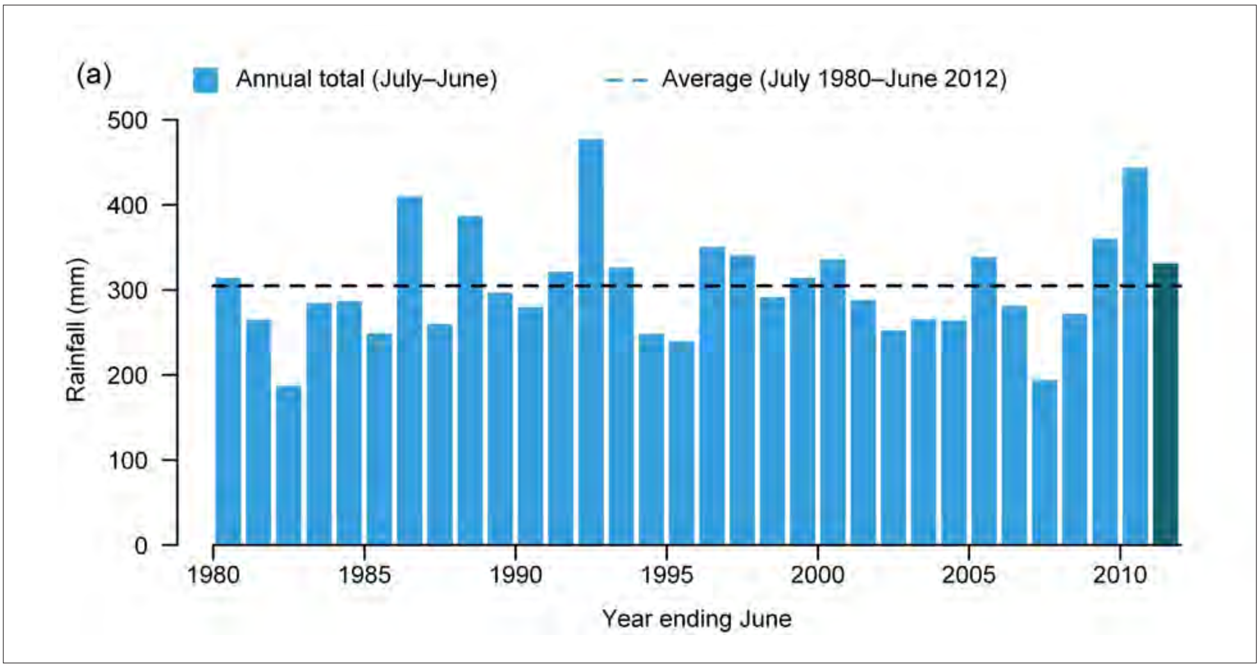



Figure 8.13 Spatial distribution of (a) annual rainfall in 2011–12, and (b) their decile rankings over the 1911–2012 period for the South Australian Gulf region

### Rainfall variability in the recent past

Figure 8.14a shows annual rainfall for the region from July 1980 onwards. Over this 32-year period the annual average was 305 mm, varying from 187 mm (1982–83) to 477 mm (1992–93). Temporal variability and seasonal patterns since 1980 are presented in Figure 8.14b.

The graphs show a pattern of moderately high variability for the region, which is linked to the highly variable rainfall pattern in the arid north of the region. In Figure 8.14b, a pattern of decreasing rainfall in the winter period and increasing rainfall in the summer period is found in the most recent years. Before this, rainfall was noticeably higher in the winter period compared to the summer period.



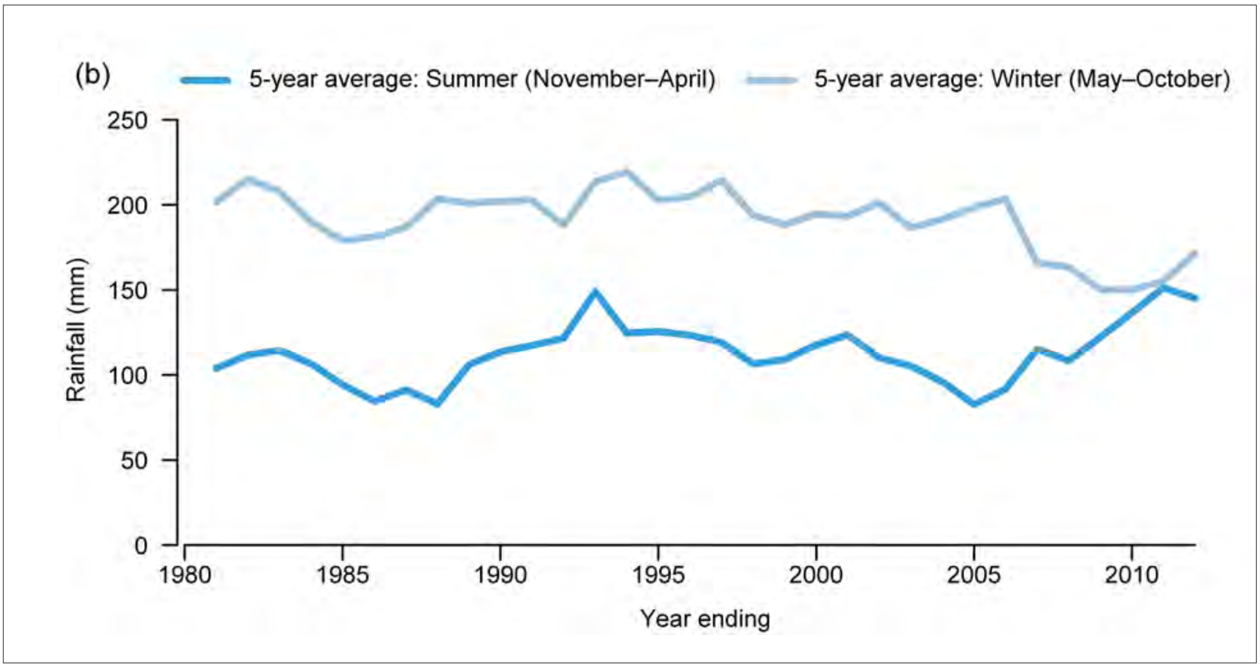




Figure 8.14 Time-series of (a) annual rainfall, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the South Australian Gulf region

## Recent trends in rainfall

Figure 8.15a presents the spatial distribution of the trends in annual rainfall for July 1980–June 2012. These are derived from linear regression analyses on the time-series of each model grid cell. The statistical significance of the trends is provided in Figure 8.15b.

Figure 8.15a shows that trends are mostly rising, but to an extent that is marginal. The significance map of Figure 8.15b confirms that the trends are of no statistical importance.

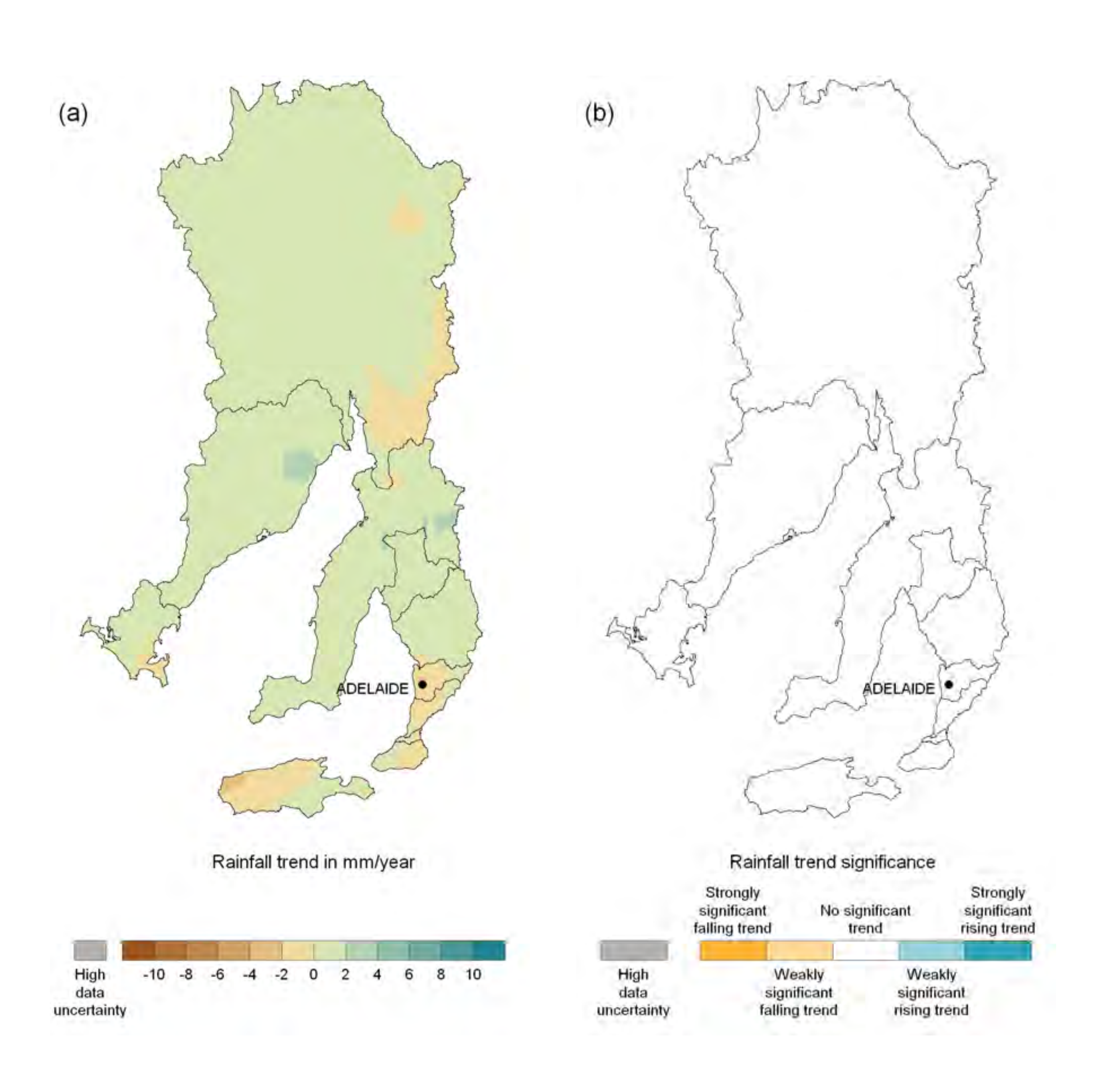



Figure 8.15 Spatial distribution of (a) trends in annual rainfall from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the South Australian Gulf region

## 8.4.2 Evapotranspiration

Modelled annual evapotranspiration for the South Australian Gulf region for 2011–12 is estimated to be 306 mm. This is 7% above the region's long-term (July 1911–June 2012) average of 286 mm. The spatial distribution of annual evapotranspiration in 2011–12 (Figure 8.16a) is almost identical to that of rainfall (Figure 8.13a). In this region, evapotranspiration is mostly limited to the availability of water.

Evapotranspiration deciles for 2011–12 indicate average or above average totals across most of the region (Figure 8.16b). The pattern again reflects that of rainfall (Figure 8.13b), albeit with some minor differences.

Essentially, those areas that had above average rainfall also had above average evapotranspiration. Hence, most water was returned back to the atmosphere within a short period of time.

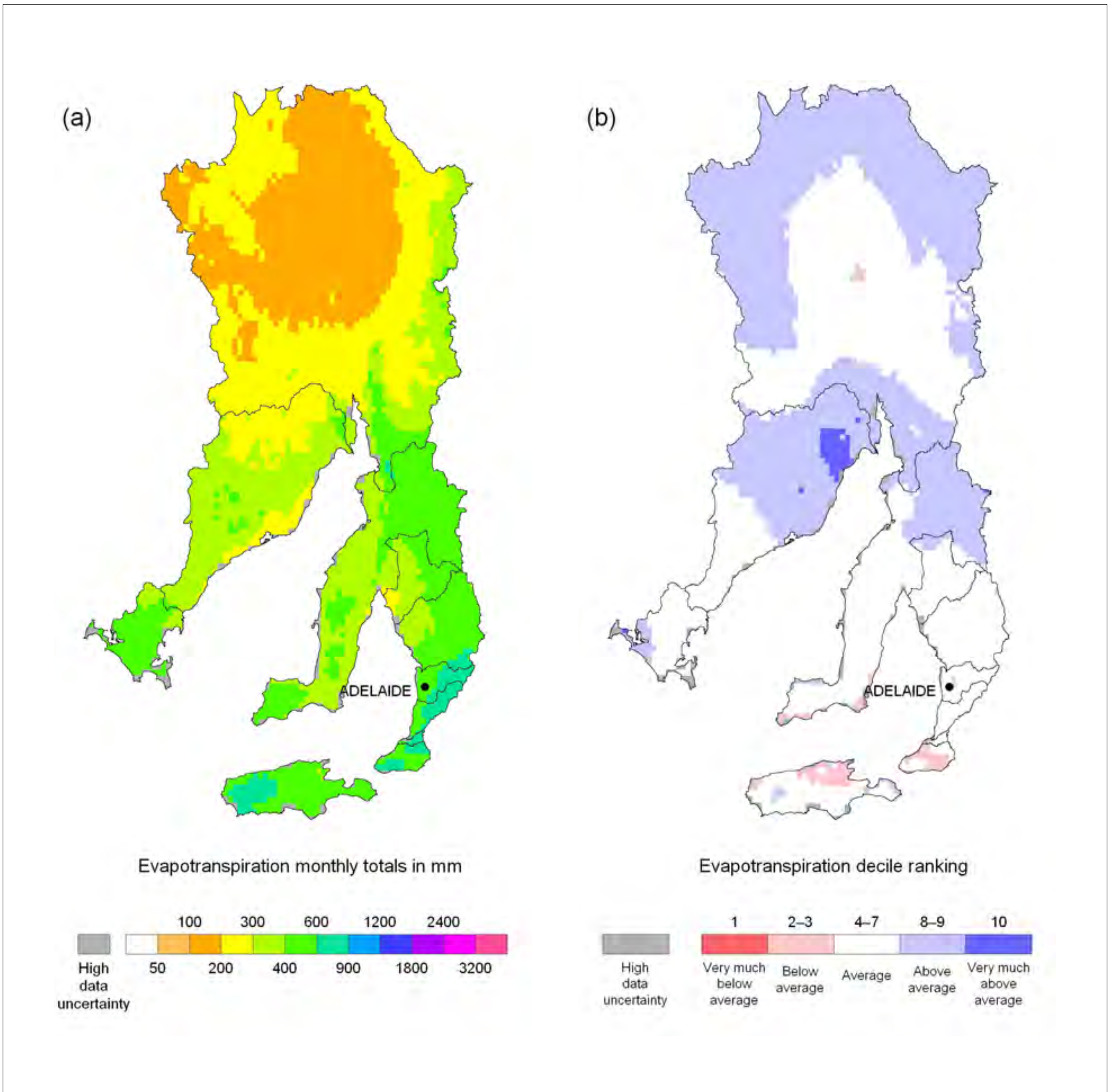



Figure 8.16 Spatial distribution of (a) modelled annual evapotranspiration in 2011–12, and (b) their decile rankings over the 1911–2012 period for the South Australian Gulf region

## Evapotranspiration variability in the recent past

Figure 8.17a shows annual evapotranspiration for the region from July 1980 onwards. Over this 32-year period the annual evapotranspiration average was 292 mm, varying from 191 mm (1982–83) to 447 mm (1992–93). Figure 8.17b presents temporal variability and seasonal patterns since 1980.

The similarity between the rainfall data of Figure 8.14 and the evapotranspiration data of Figure 8.17 is high. Evapotranspiration also shows a narrowing of the difference between the summer and winter periods over the last few years.

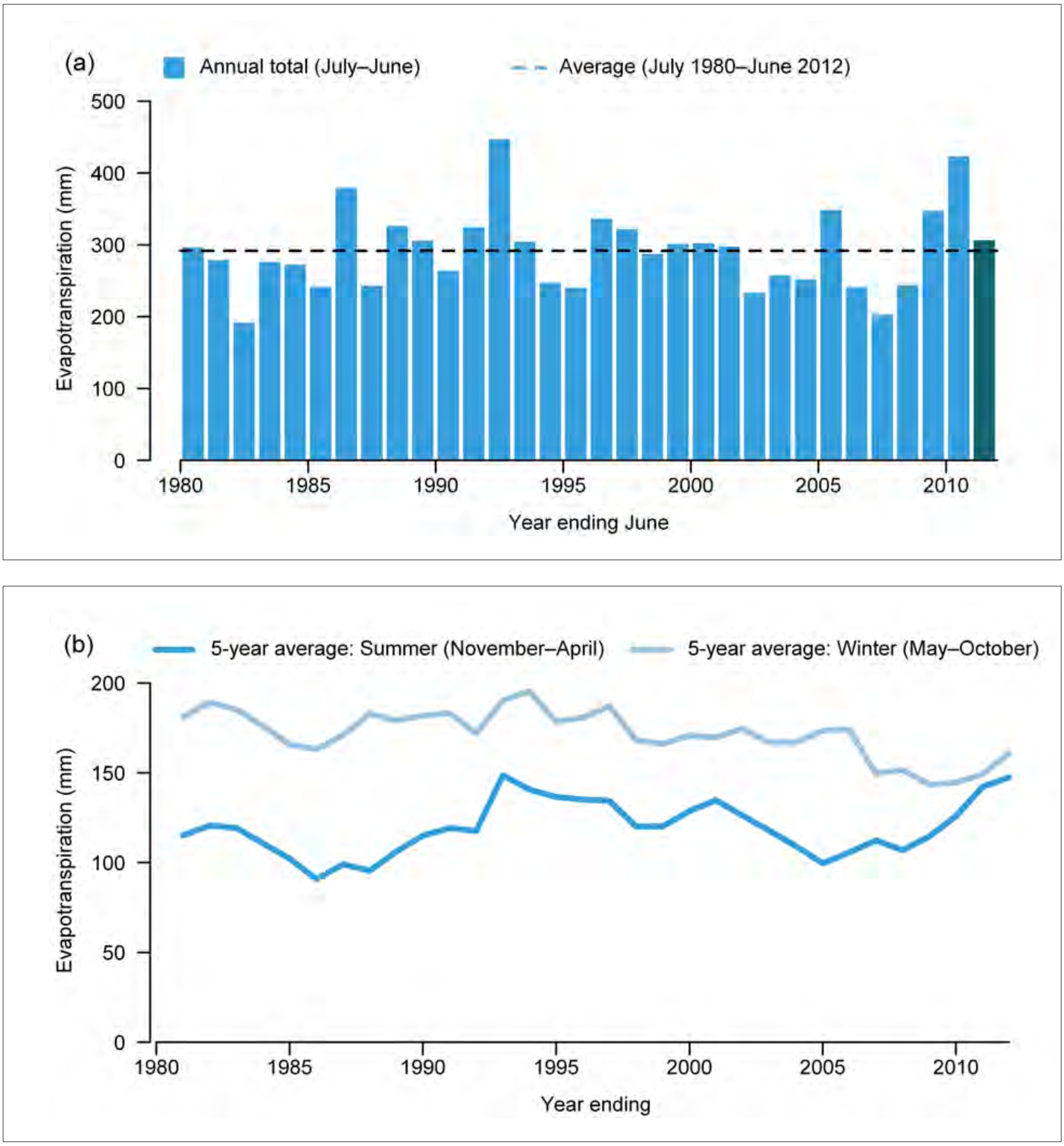



Figure 8.17 Time-series of (a) annual evapotranspiration, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the South Australian Gulf region

### Recent trends in evapotranspiration

Figure 8.18a presents the spatial distribution of the trends in modelled annual evapotranspiration for 1980–2012. These are derived from linear regression analyses on the time-series of each model grid cell. Figure 8.18b provides the statistical significance of the trends.

Figure 8.18a shows that since 1980 trends throughout the region are within the –2 to 2 mm/year range.

As shown in Figure 8.18b, the trends are non-significant throughout the region. A major reason for this is that unlike in many other regions, the last two years were not the highest on record for the 32-year period.

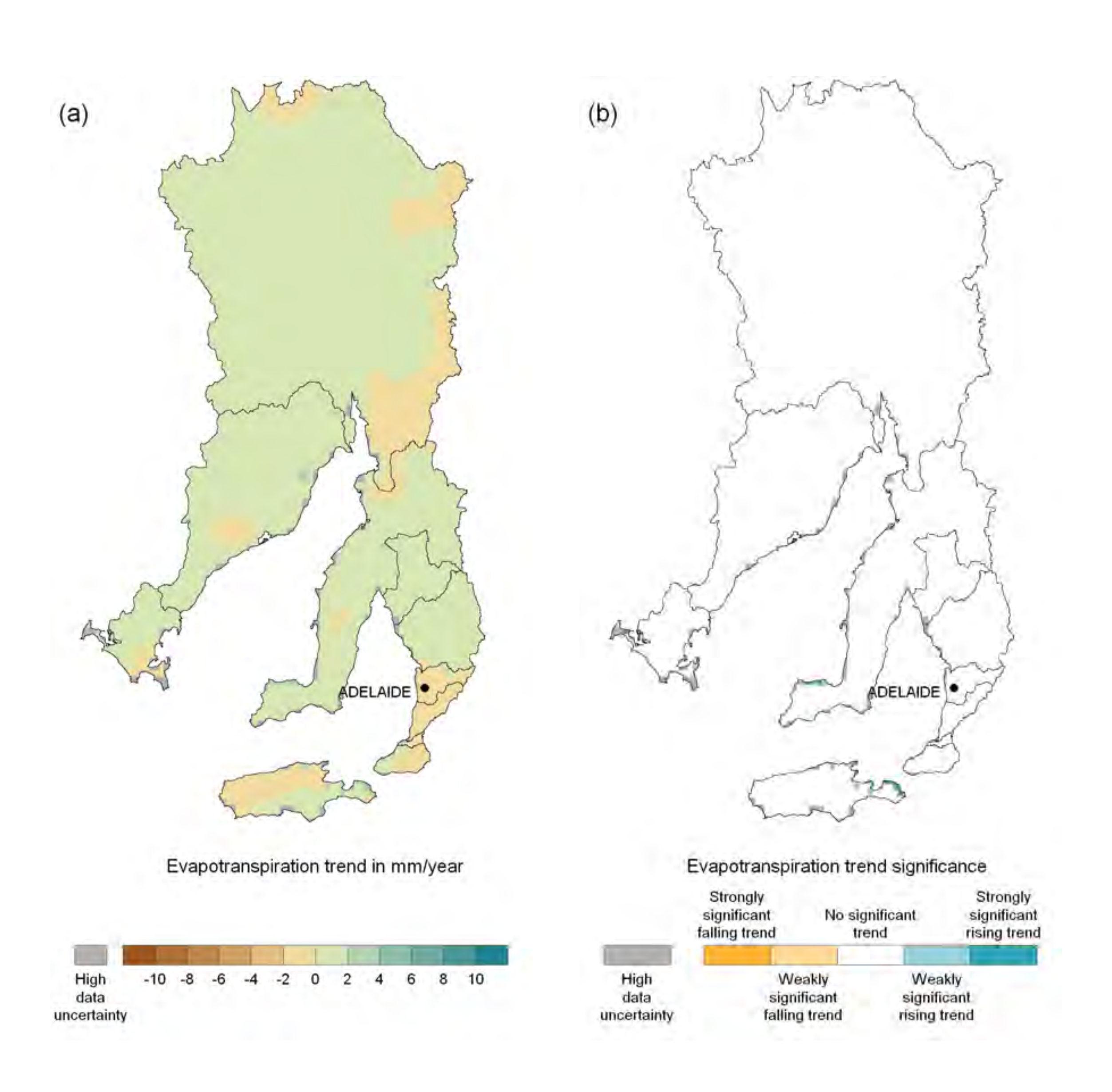



Figure 8.18 Spatial distribution of (a) trends in annual evapotranspiration from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the South Australian Gulf region

## 8.4.3 Landscape water yield

Modelled landscape water yield for the South Australian Gulf region for 2011–12 is estimated to be 9 mm. This is 10% below the region's long-term (July 1911–June 2012) average of 10 mm. Figure 8.19a shows the spatial distribution of landscape water yield for 2011–12. Only in the far southeast and on Kangaroo Island did some areas have landscape water yields exceeding 50 mm.

The decile ranking map for 2011–12 (Figure 8.19b) shows very much above average landscape water yield for the far north of the region. In absolute terms, however, these areas still had very low landscape water yield. In the far south some coastal areas are highlighted as very much below average landscape water yield; however, this is likely an artefact of the model calculations, which has yet to be further investigated.

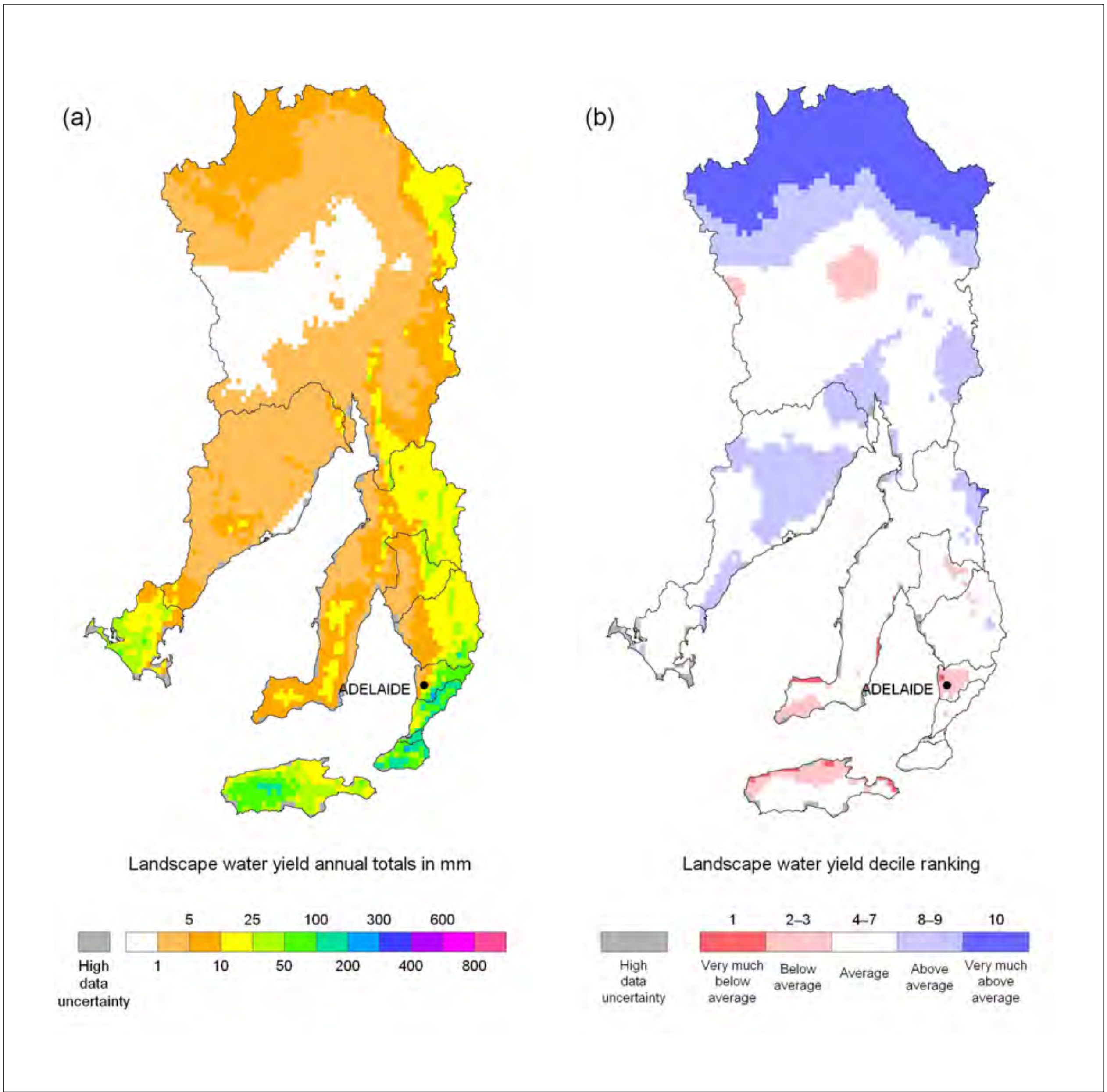
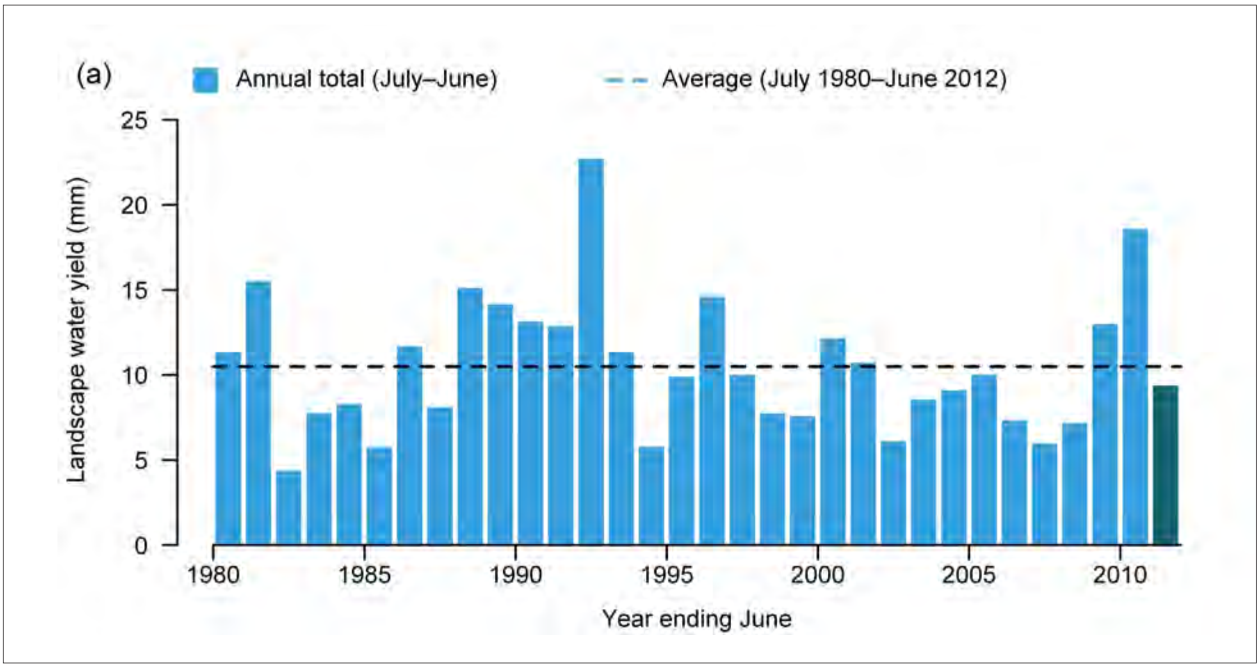



Figure 8.19 Spatial distribution of (a) modelled annual landscape water yield in 2011–12, and (b) their decile rankings over the 1911–2012 period for the South Australian Gulf region

### Landscape water yield variability in the recent past

Figure 8.20a shows annual landscape water yield for the South Australian Gulf region from July 1980 onwards. Over this 32-year period, annual landscape water yield was 10 mm, varying from 4 mm (1982–83) to 23 mm (1992–93). Temporal variability and seasonal patterns since 1980 are presented in Figure 8.20b.

The graphs show a weak pattern of cyclic behaviour in the annual as well as summer and winter periods landscape water yield. Figure 8.20a shows that landscape water yields for some years were around 5 mm or lower, which generally means that in the arid north of the region landscape water yield was close to zero for those years.



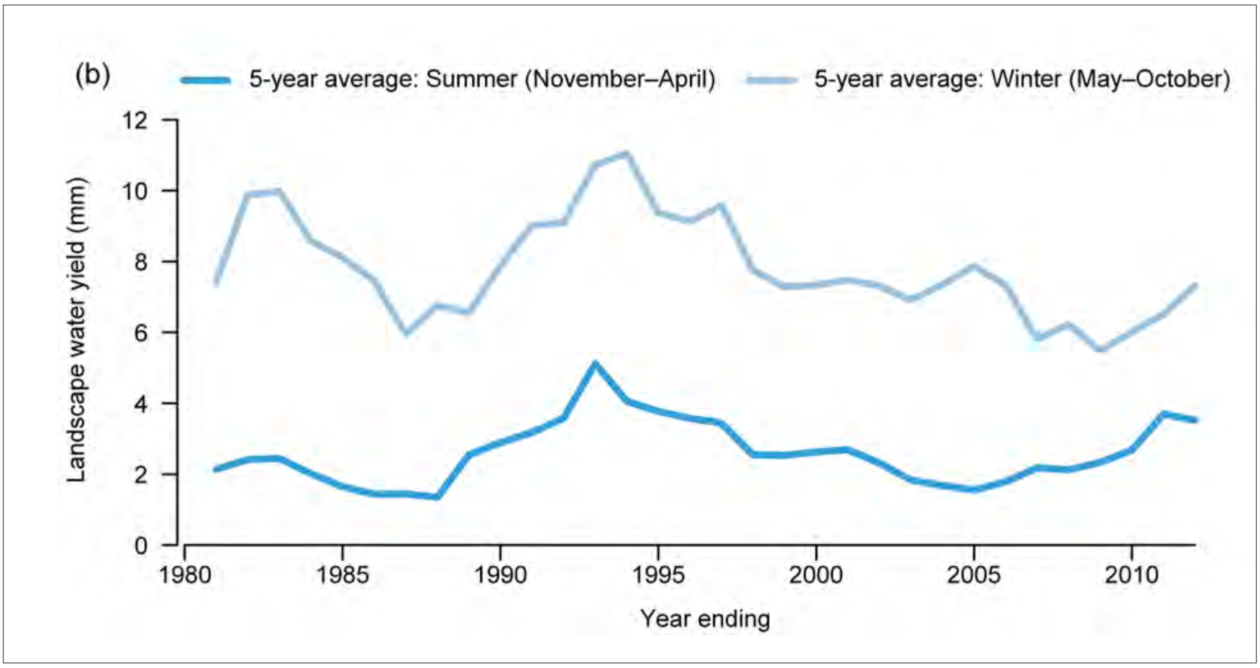




Figure 8.20 Time-series of (a) annual landscape water yield and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the South Australian Gulf region

### Recent trends in landscape water yield

Figure 8.21a shows the spatial distribution of the trends in modelled annual landscape water yield for 1980–2012. These are derived from linear regression analyses on the time-series of each model grid cell. The statistical significance of the trends is provided in Figure 8.21b.

Similar to rainfall and evapotranspiration, Figure 8.21a shows that since 1980 trends were within the –2 and 2 mm/year margins. With such low total annual landscape water yields involved, this is not surprising.

Figure 8.21b, however, shows some strongly significant rising trends occurring mainly in the central west of the region and in the southern part of Yorke Peninsula. In absolute terms, though, the trends do not exceed 0.2 mm/year in the central western area and 0.5 mm/year on Yorke Peninsula. The strongly significant falling trends on Kangaroo Island do not exceed –1 mm/year.

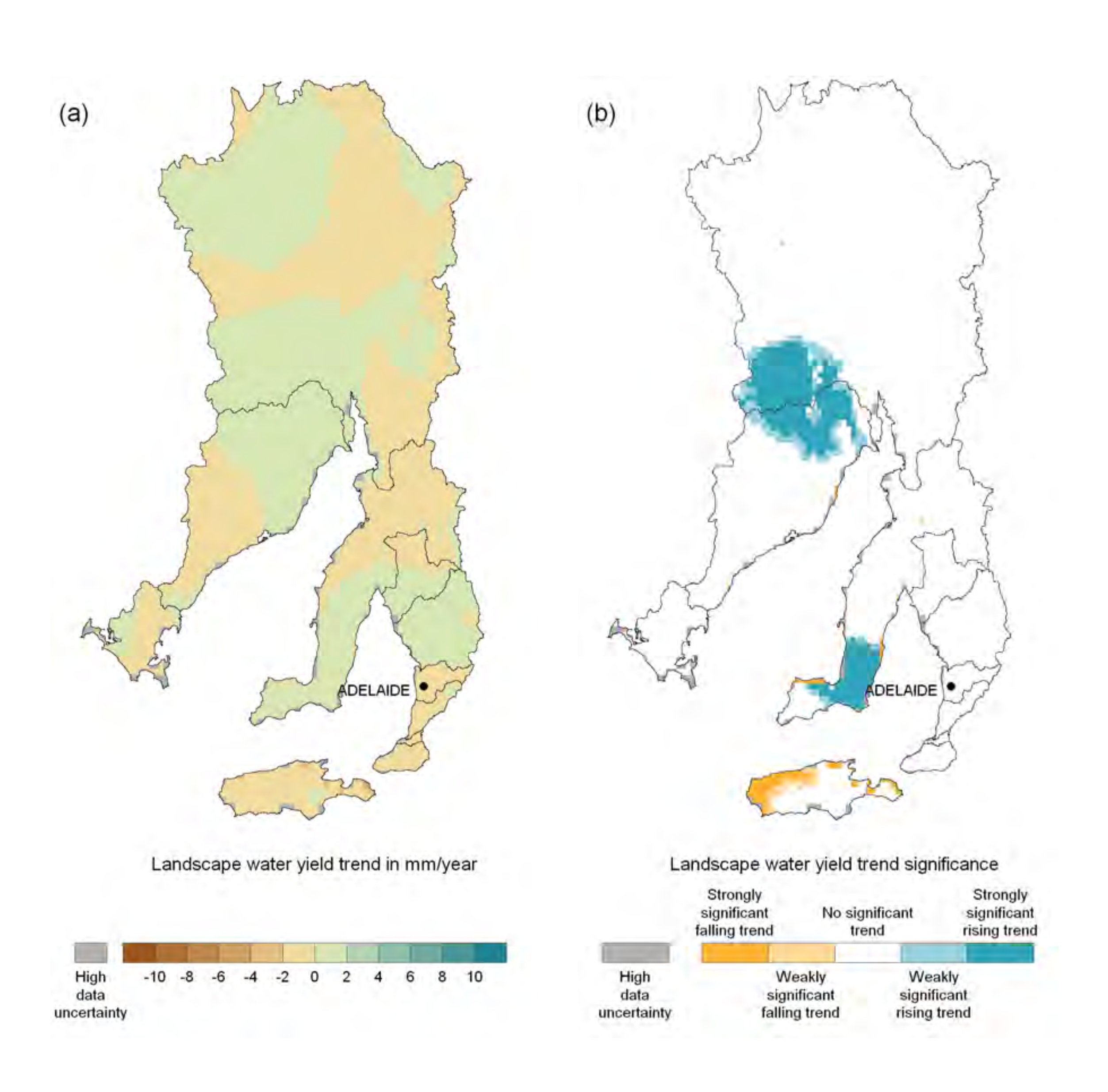



Figure 8.21 Spatial distribution of (a) trends in annual landscape water yield from 1980 to 2012 and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the South Australian Gulf region

## 8.5 Surface water and groundwater

This section examines surface water and groundwater resources in the South Australian Gulf region in 2011–12. Rivers, wetlands and storages are discussed to illustrate the state of the region's surface water resources. The region's watertable aquifers and salinity are described and the groundwater status is illustrated by showing changes in groundwater levels at selected sites.

### 8.5.1 Rivers

There are 11 river basins in the South Australian Gulf region, varying in size from 154–67,000 km$^2$ (Figure 8.22).

In the west and north, rivers are ephemeral and in the south east corner a few are perennial. There are only minor ephemeral streams in the northern half of the region.

To the southeast of the region, short rivers drain into the ocean. The perennial rivers flow off the slopes of the Mount Lofty Ranges into the Spencer Gulf. In the west, watercourses like the ephemeral Driver River flow from various low hills parallel to the coast on Eyre Peninsula. In the north, the Flinders Ranges supply most of the run-off from the east into Lake Torrens. Undulating land that averages less than 200 m above sea level, including the Andamooka Ranges, supplies the salt lake from the west.

Torrens River, Adelaide | Deqiang Pan, Dreamstime


Figure 8.22 Rivers and catchments in the South Australian Gulf region

### 8.5.2 Streamflow volumes

Figure 8.23 presents an analysis of flows at 14 monitoring sites during 2011–12 relative to annual flows for the period from July 1980–July 2012. Monitoring sites with relatively long records across six geographically representative rivers were selected (see the Technical Supplement for details). The annual flows for 2011–12 are colour-coded according to the decile rank at each site over the 1980–2012 period.

The flows are mostly average to above average and with some rivers showing very much below average annual flow for 2011–12.

Very much above average flows were observed at two sites located on the South Para River in the southeast and the Hindmarsh River in the far southeast of the South Australian Gulf region. Of the 15 monitoring sites, only one recorded above average flows. This site was on the Hill River near Andrews in the Broughton River basin in the central southeast of the region.

Average flows occurred at seven monitoring sites in the region. These are located on rivers in the southeast and on the Rocky River on Kangaroo Island.

There was only one site where below average flows were recorded. This was on the Myponga River in the far southeast of the region. Very much below average flows were observed at three sites, which are located on the rivers in the central-southeast and on the Onkaparinga River in the southeast.

Flow deciles for the summer period (November 2011–April 2012) are similar to total annual flows for 2011–12 as shown in Figure 8.23. There are a few differences, such as the relatively higher flows observed in the summer period on the Onkaparinga River in the east of the region.

### 8.5.3 Streamflow salinity

Figure 8.24 presents an analysis of streamflow salinity for 2011–12 at 14 monitoring sites throughout the South Australian Gulf region. Monitoring sites with at least a five-year data record were selected for analysis. The results are presented as electrical conductivity (EC, µS/cm at 25 °C). This is a commonly used surrogate for the measurement of water salinity in Australia. Standard EC levels for different applications, such as for drinking water or types of irrigation, are provided in the Technical Supplement. The median annual EC values are shown as coloured circles. The size of the circle depicts the variability in annual EC, shown as the coefficient of variation (CV), being the standard deviation divided by the mean.

The median EC values for two monitoring sites in the main rivers fall in the range 0–1,000 µS/cm (suitable for most irrigation uses). Most of the region's rivers and creeks fall outside this range (Figure 8.24).

Of the 14 monitoring sites, two had median EC values between 500–1,000 µS/cm and a further two had values between 1,000–1,500 µS/cm. These are located on the rivers in the far southeast of the region. Of the 14 sites, 71% had median EC values above 2000 µS/cm. These are located on the rivers in the southeast, central southeast and at three sites on Kangaroo Island. The high salinity found in some rivers is a reflection of natural conditions which are influenced by the dry climate, natural salt stores in the landscape and naturally high saline groundwater intrusion which is suitable for most irrigation uses (State of the Environment 2011).

The CV is relatively low for the most of the monitoring sites in the region except for Tanunda Creek. The CV in EC is typically related to the variability in annual flow at the monitoring site. Of the 14 monitoring sites, 21% of them had a CV below 20%, and 71% of the sites had a CV between 20% and 60%. These were located on the rivers in the southeast, central south and on Kangaroo Island. The CV was above 60% in Tanunda Creek in the southeast of the region.

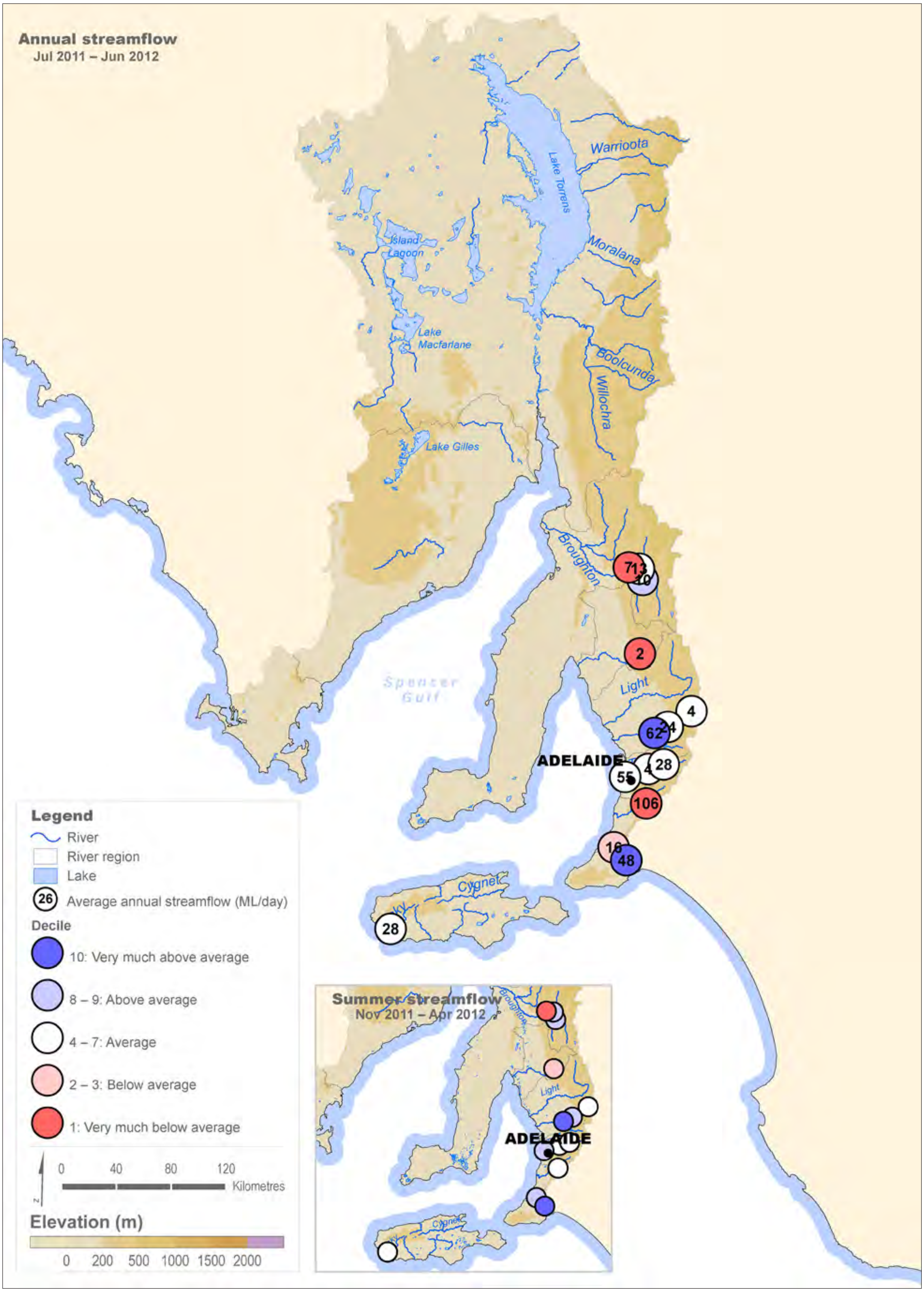



Figure 8.23 Average annual and summer period flow volumes of selected sites for 2011–12 and their decile rankings over the 1980–2012 period in the South Australian Gulf region

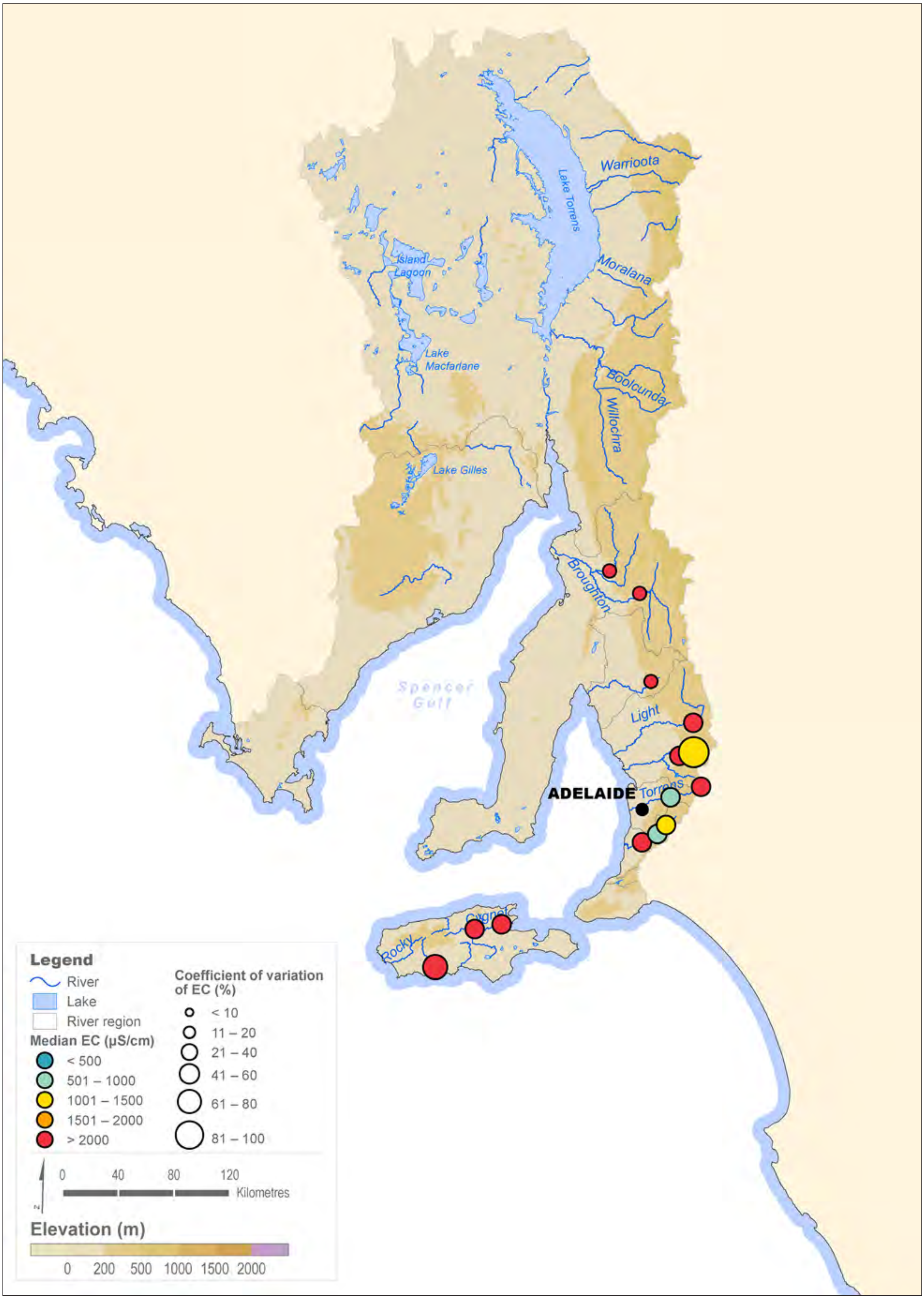



Figure 8.24 Salinity as electrical conductivity and its associated coefficient of variation for 2011–12 in the South Australian Gulf region

### 8.5.4 Flooding

There were no major floods recorded for the South Australian Gulf region during the reporting year. Minor flooding occurred only in local creeks in July and September 2011 and in March 2012 (Figure 8.25).

### 8.5.5 Storage systems

There are approximately 16 major publicly owned storages in the South Australian Gulf region with a total capacity in excess of 268 GL. The Bureau's water storage website includes information on approximately 74% of the region's publicly owned storage capacities (as at August 2012)

All of the storages in the Bureau's water storage information for this region supply the city of Adelaide, adding up to a total accessible capacity of 197 GL. At the end of 2010–11, storage levels were at 135 GL (69% of total accessible capacity), but by the end of 2011–12 this had dropped to 96 GL (49% of total accessible capacity). The location of all the systems and associated storages are shown in Figure 8.26.

The city of Adelaide is not fully dependent on storage water supply only. A large portion of the city's water supply originates from transfers out of the River Murray, which has recently been complemented by desalinated water; however, the decrease in storage levels by 20% is not a favourable situation. This is reflected in stricter water conservation rules.

More detailed information on the Adelaide water supply system is given in subsection 8.6, Water for cities and towns. Further information on the past and present volumes of the storage systems and the individual storages can be found on the Bureau's water storage website: water.bom.gov.au/waterstorage/awris/

### 8.5.6 Wetlands

There are no Ramsar-listed, internationally important wetlands in the South Australian Gulf region; however, there are a number of wetlands of national importance mentioned in the *Directory of Important Wetlands in Australia* (www.environment.gov.au/water/topics/wetlands/database/diwa.html). The wetlands vary from coastal tidal flats to inland ephemeral lakes and large salt lakes (Figure 8.27). No detailed assessment on the inflows of selected wetlands has been performed for this region.

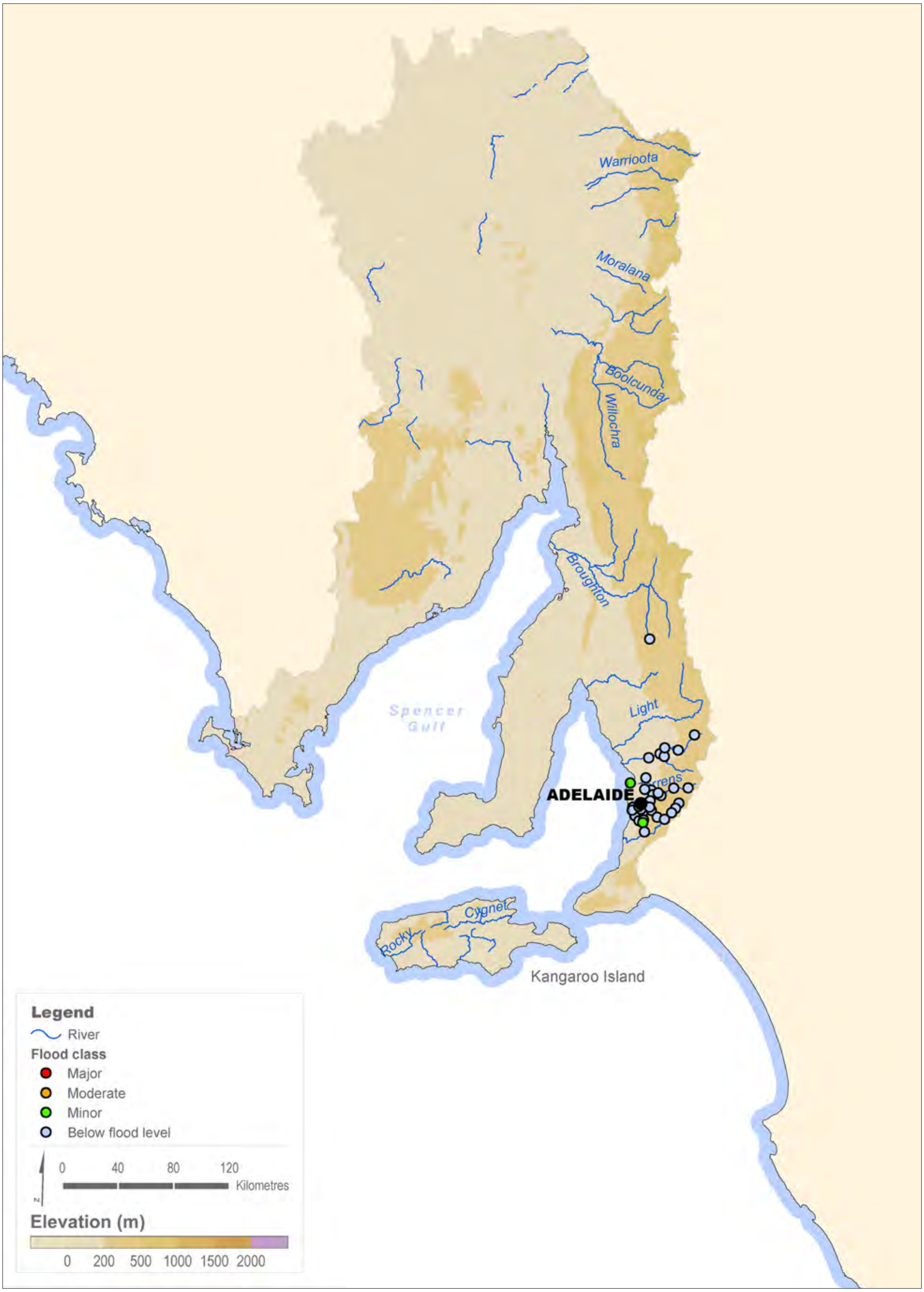



Figure 8.25 Flood occurrence in 2011–12 for the South Australian Gulf region, with each dot representing a river level monitoring station and the colour of the dot representing the highest flood class measured

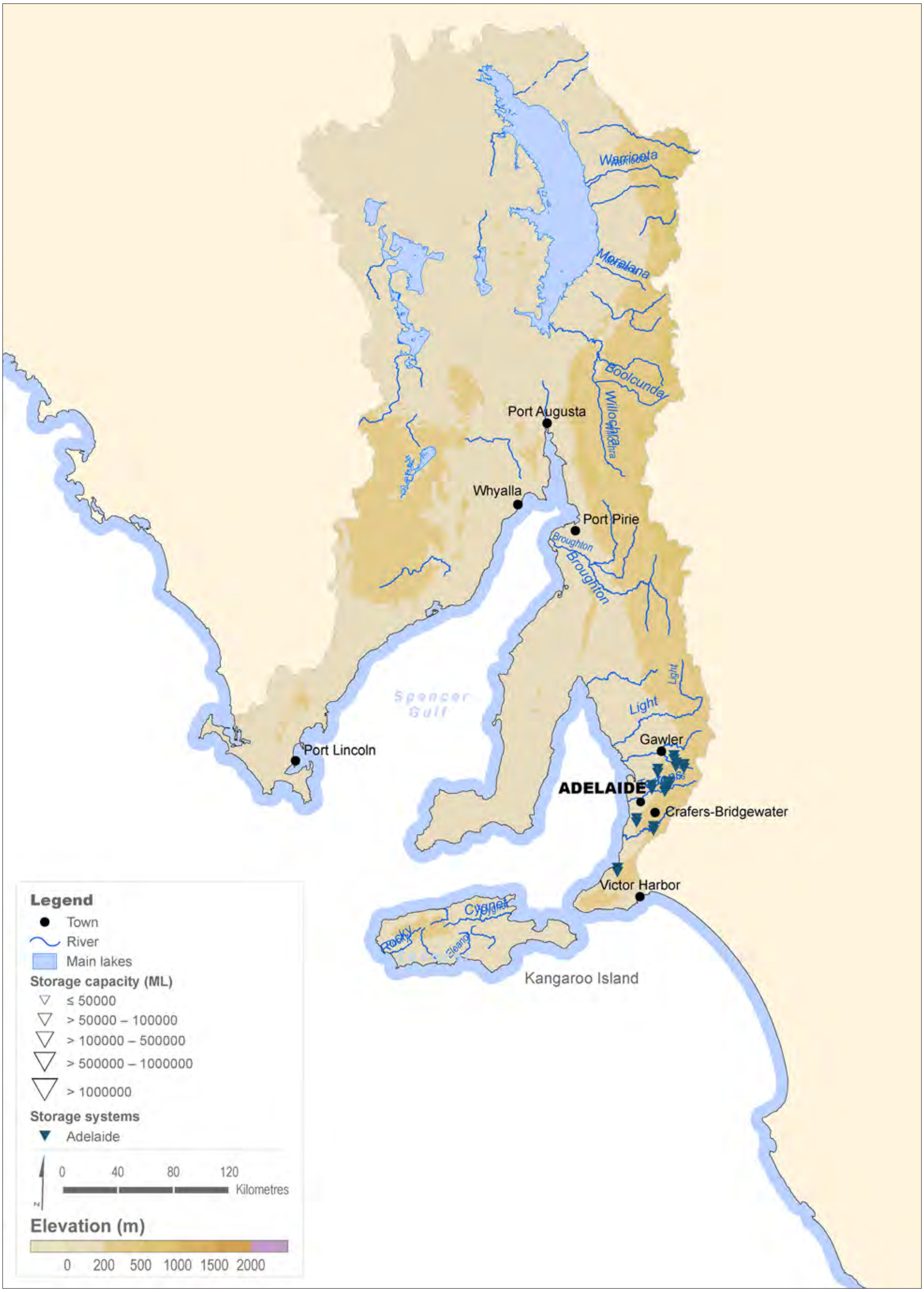



Figure 8.26 Storage systems in the South Australian Gulf region (information extracted from the Bureau's water information website in August 2012)

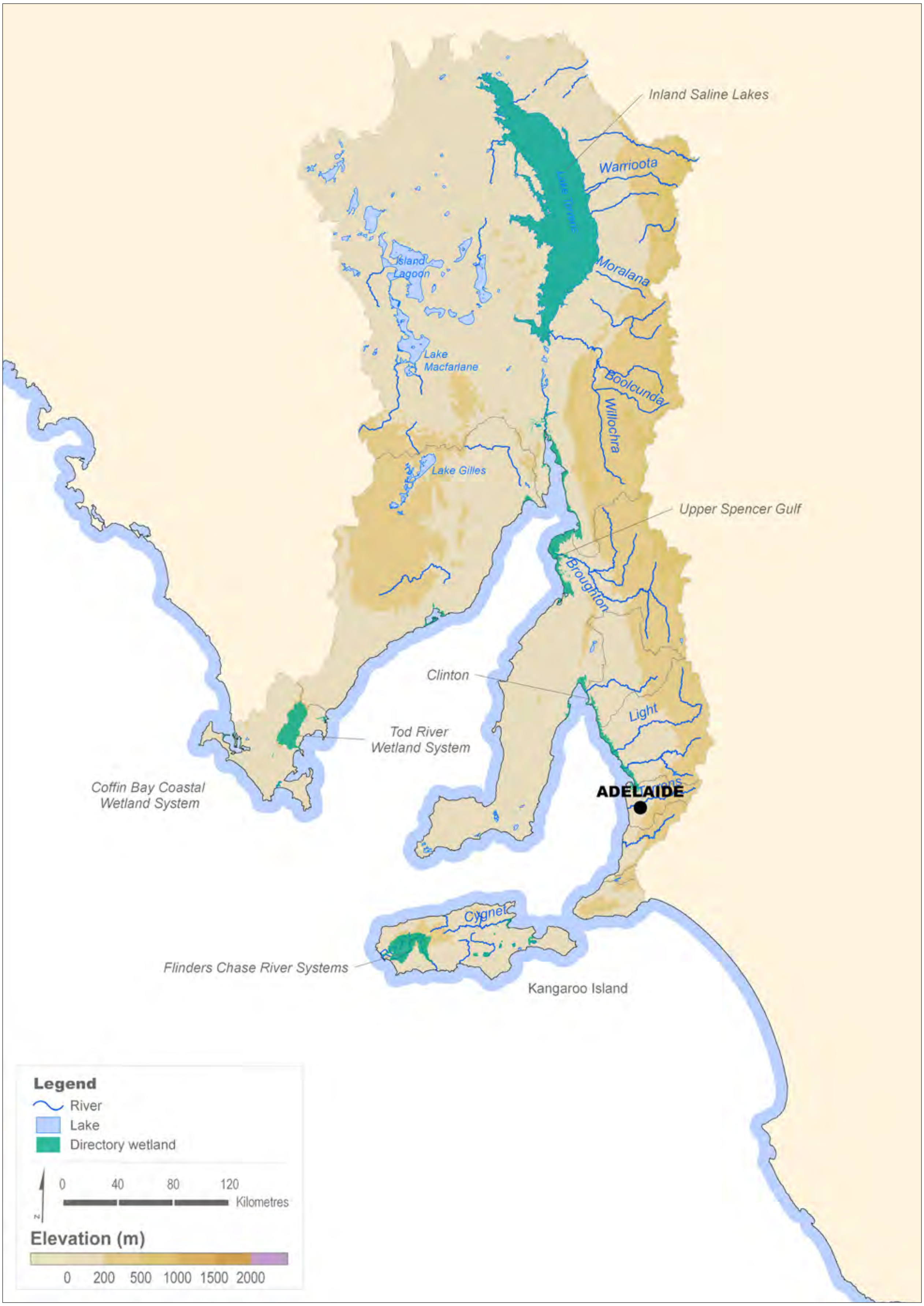



Figure 8.27 Location of important wetlands in the South Australian Gulf region

## 8.5.7 Hydrogeology

The hydrogeology of the South Australian Gulf region can be partitioned into areas of surficial and underlying sediments, and areas of outcropping fractured rock.

Groundwater use in the region is largest in areas with surficial sediments and underlying aquifers. Figure 8.28 shows major aquifer groups present at the watertable. Aquifer groups that provide potential for groundwater extraction (as labelled in Figure 8.2) are:

- lower mid-Tertiary aquifer ; (porous media— unconsolidated)
- upper Tertiary aquifer (porous media— unconsolidated); and
- upper Tertiary/Quaternary aquifer (porous media—unconsolidated).

The sediments of the Great Artesian Basin are present along the northern boundary of the region but are not dominant for water provision.

## 8.5.8 Water table salinity

Figure 8.29 shows the classification of watertable aquifers as fresh (total dissolved solids [TDS] < 3,000 mg/L) or saline (TDS ≥ 3,000 mg/L). As shown, most parts of the region are considered to have saline groundwater that is usually not suitable for irrigation. Non-saline groundwater occurs in the east of the region and in particular around the Adelaide area.

## 8.5.9 Groundwater management units

The groundwater management units within the region (Figure 8.30) are administrative boundaries that are used to manage the extraction of groundwater through planning mechanisms. These areas are usually created to identify a significant groundwater resource and to provide a boundary within which resource management effort can be focused. Prescription is the legal mechanism for implementing a water resource management regime in South Australia. A prescribed water resource is managed through an allocation and licensing system where the emphasis is on groundwater. These areas are known as water resources prescribed areas and prescribed wells areas within South Australia.

Groundwater management units are found in areas with significant fresh groundwater resources. These are the surficial sediments and the underlying Quaternary and Tertiary aquifers. The fractured rock systems typically offer restricted low volume groundwater resources; however, there are some parts of this region with a greater density of fractures and more substantial groundwater resources. Typically, groundwater use is high in prescribed wells areas such as McLaren Vale, the northern and central Adelaide Plains, and the southern basins.

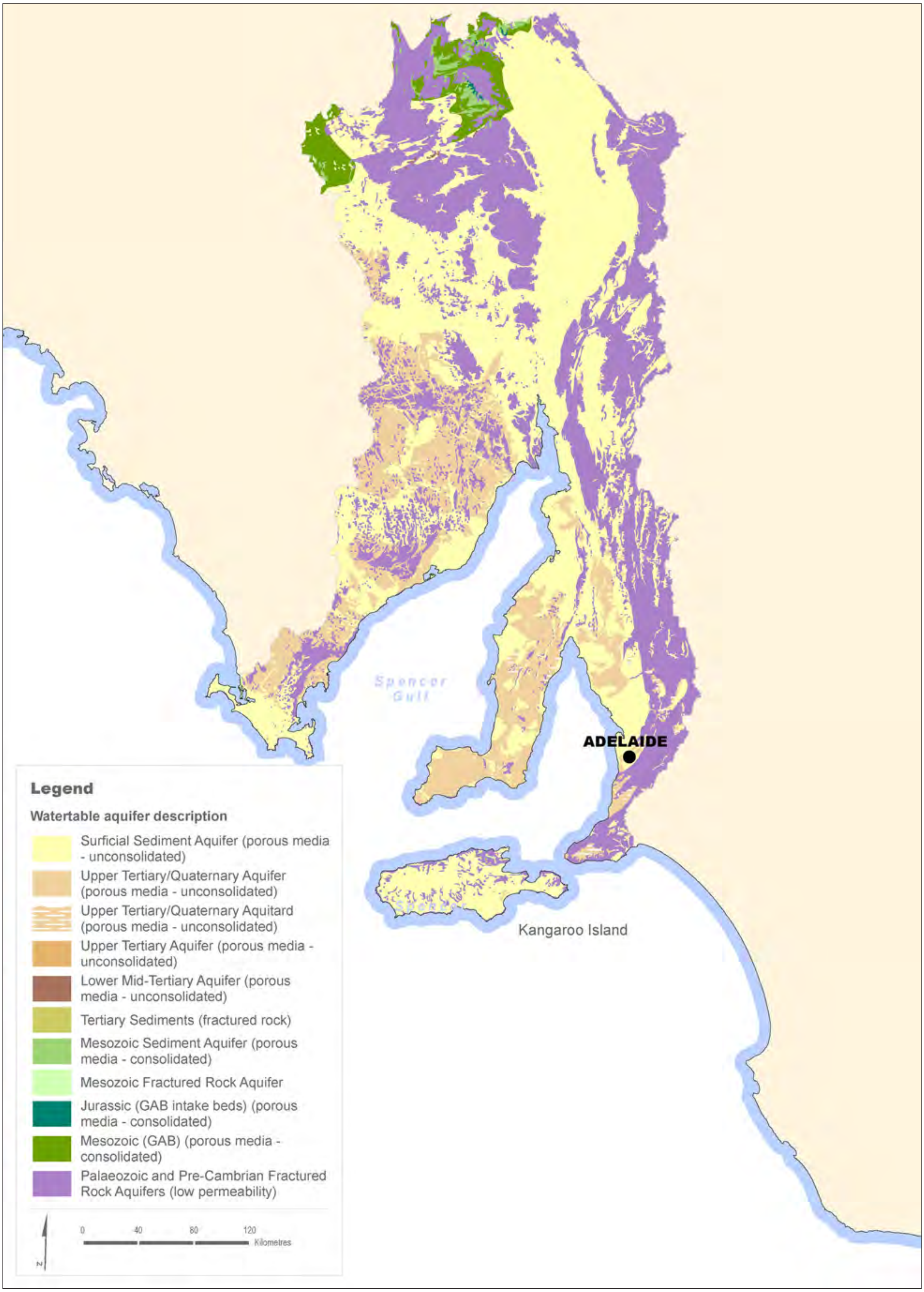



Figure 8.28 Watertable aquifer groups in the South Australian Gulf region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

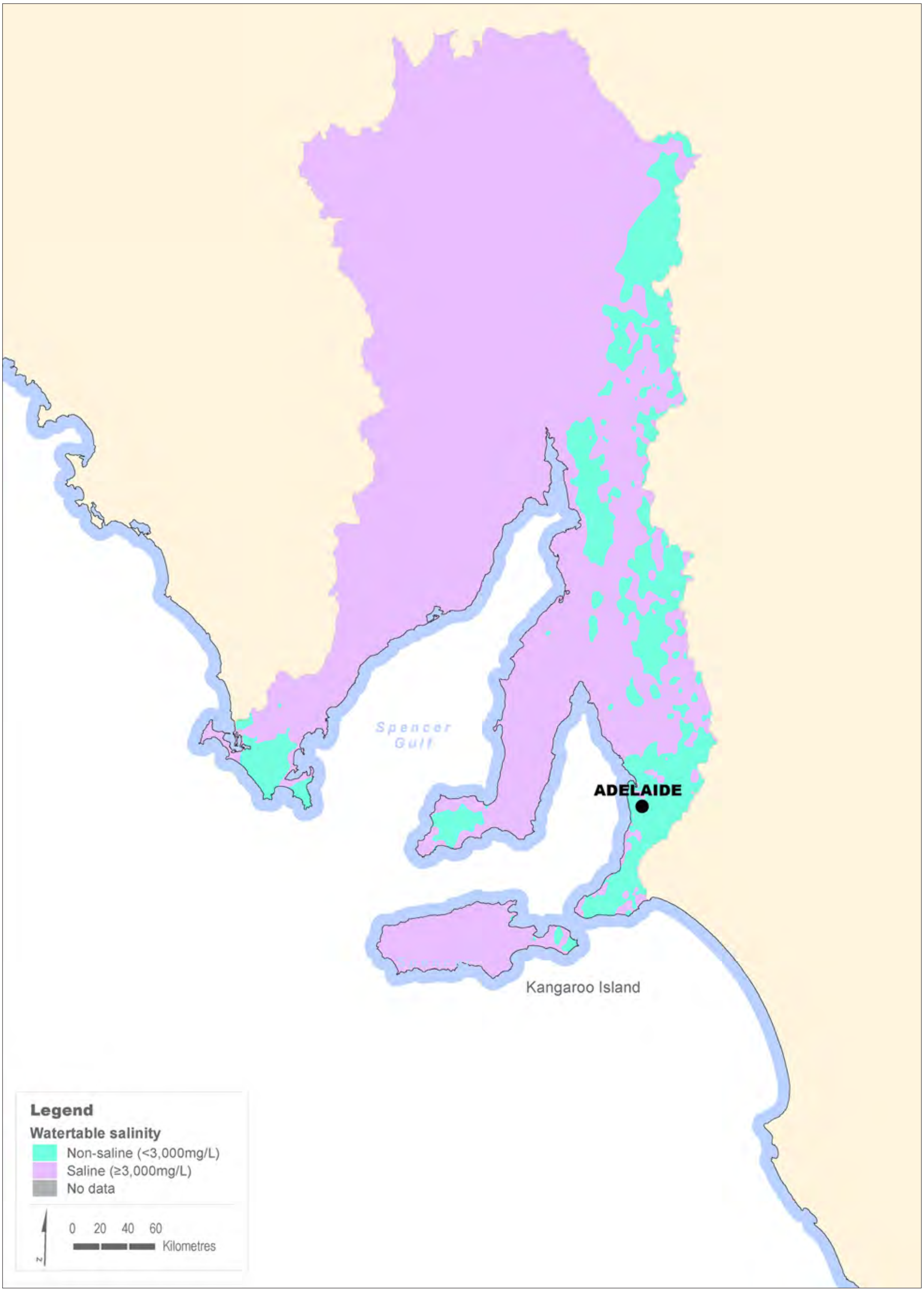



Figure 8.29 Watertable salinity classes in the South Australian Gulf region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2013)

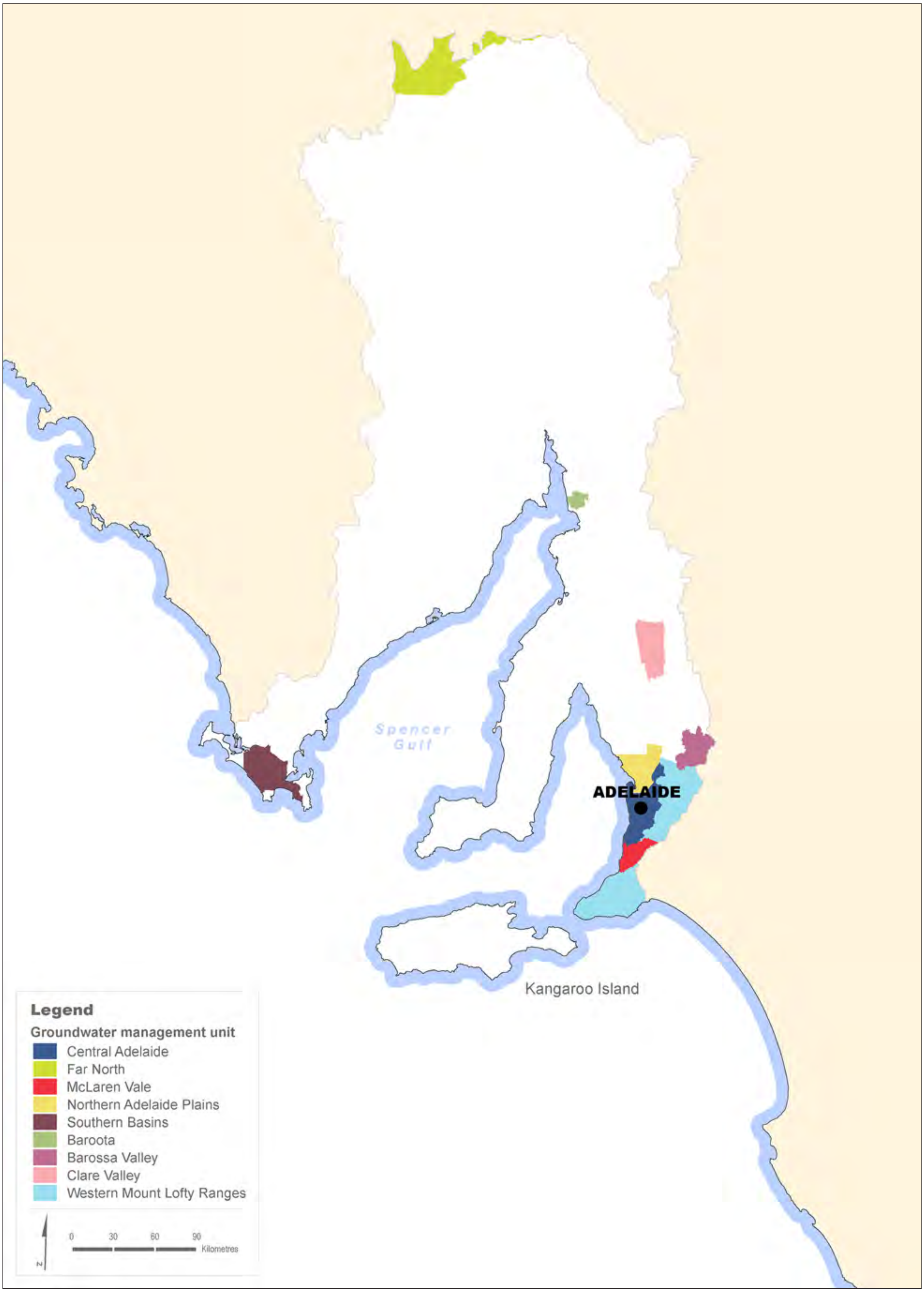



Figure 8.30 Groundwater management units in the South Australian Gulf region; data extracted from the National Groundwater Information System (Bureau of Meteorology 2013)

## 8.5.10 Status of selected aquifers

The status of groundwater levels is assessed for the Adelaide Plains and McLaren Vale aquifers which are major groundwater resources for the region. These aquifers are associated with three of the most important groundwater management units (prescribed well areas) shown in Figure 8.30. The assessment of groundwater levels evaluates trends in groundwater levels over the 2007–08 to 2011–12 period.

The trends in groundwater levels are investigated using a 5 km x 5 km grid cell across data rich areas. This scale reflects the size of the selected aquifers in the region. The linear trend in groundwater levels for a grid cell is assessed as:

- decreasing (where more than 60% of the bores have a negative trend in levels lower than –0.1 m/year);
- stable (where the trend is lower than 0.1 m/year and higher than –0.1 m/year for more than 60% of the bores);
- increasing (where more than 60% of the bores have a positive trend in levels higher than 0.1 m/year); and
- variable (where there is no dominant trend in groundwater levels amongst the bores within a grid cell).

Example bore hydrographs are presented for each aquifer over the entire record length and trends are discussed with a focus on the 2007–08 to 2011–12 period. The selected bore hydrographs represent mostly bores with high data density that were used in the 2010 Assessment. Aquifers considered:

- Adelaide Plains watertable
- Adelaide Plains Tertiary aquifer 1 (T1)
- Adelaide Plains Tertiary aquifer 2 (T2)
- McLaren Vale watertable
- Willunga
- Maslin.

### Adelaide Plain aquifers

Figure 8.31 illustrates the spatial and temporal grid analyses of trends in groundwater levels of the Adelaide watertable over the period 2007–08 to 2011–12. Trends in groundwater levels were analysed in data-rich areas only. As shown in Figure 8.31, in the north of the aquifer groundwater levels are mostly rising. This reflects the increased groundwater recharge due to the recent high rainfall.

Selected bores 1 and 2 show variability in groundwater levels but no significant trend over the period. Peaks in water levels in these two bores represent groundwater response to infrequent recharge events. In contrast, Bore 3 shows stable levels until 2010. All bores show an increase in groundwater level after 2010 indicating recharge to groundwater during the recent high rainfall period.

Figure 8.32 illustrates the spatial and temporal grid analyses of trends in groundwater levels for the Tertiary aquifer T1 over the period 2007–08 to 2011–12. The trend analysis for the south of the aquifer indicates that groundwater levels for the past five years are either declining or variable. This is most likely in response to groundwater extraction in the southern area.

The selected hydrographs 4–6 indicate that variability in levels within a year is much larger than the inter-annual trend in levels. This illustrates the seasonal cycles of pumping and recovery of groundwater levels at the end of pumping season. All selected bores show a declining trend for the period 2007–08 to 2009–10 period and various degrees of recovery of groundwater levels, and therefore recharge, associated with higher rainfall since 2010.

Figure 8.33 illustrates the spatial and temporal grid analyses of trends in groundwater levels for the Tertiary aquifer T2 over the period 2007–08 to 2011–12. The analysis for T2 aquifer is focused in the north of the aquifer, and shows that groundwater levels for the past five years are either increasing or variable, similary to the watertable aquifer. All selected bores show declining trends for the period 2007–08 to 2009–10 and some degree of recovery thereafter.

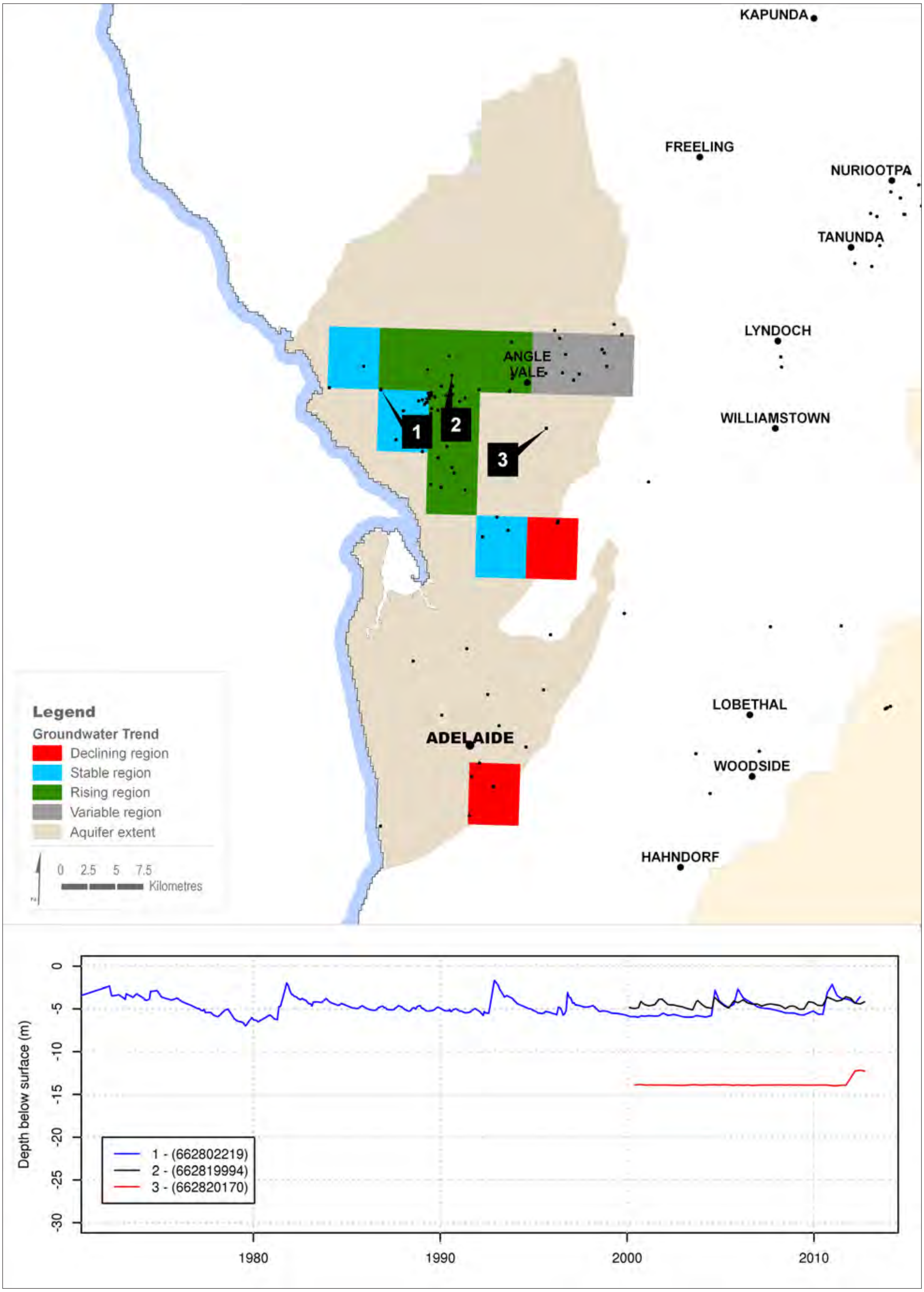



Figure 8.31 Spatial distribution of trends in groundwater levels for the Adelaide Plains watertable in the South Australian Gulf region for 2007–08 to 2011–12, with selected hydrographs showing groundwater levels

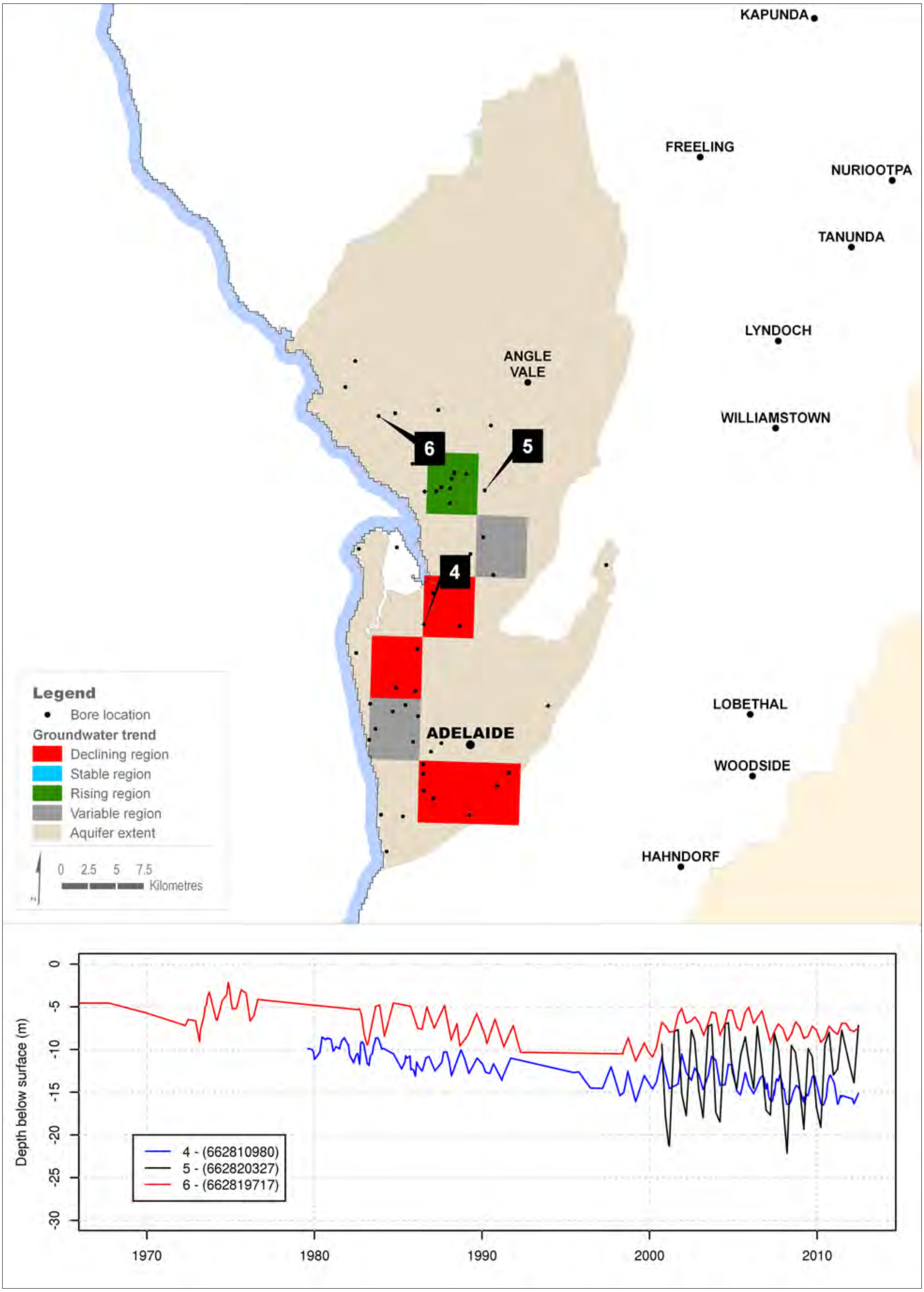



Figure 8.32 Spatial distribution of trends in groundwater levels for the Adelaide Plains T1 aquifer in the South Australian Gulf region for 2007–08 to 2011–12, with selected hydrographs showing groundwater levels

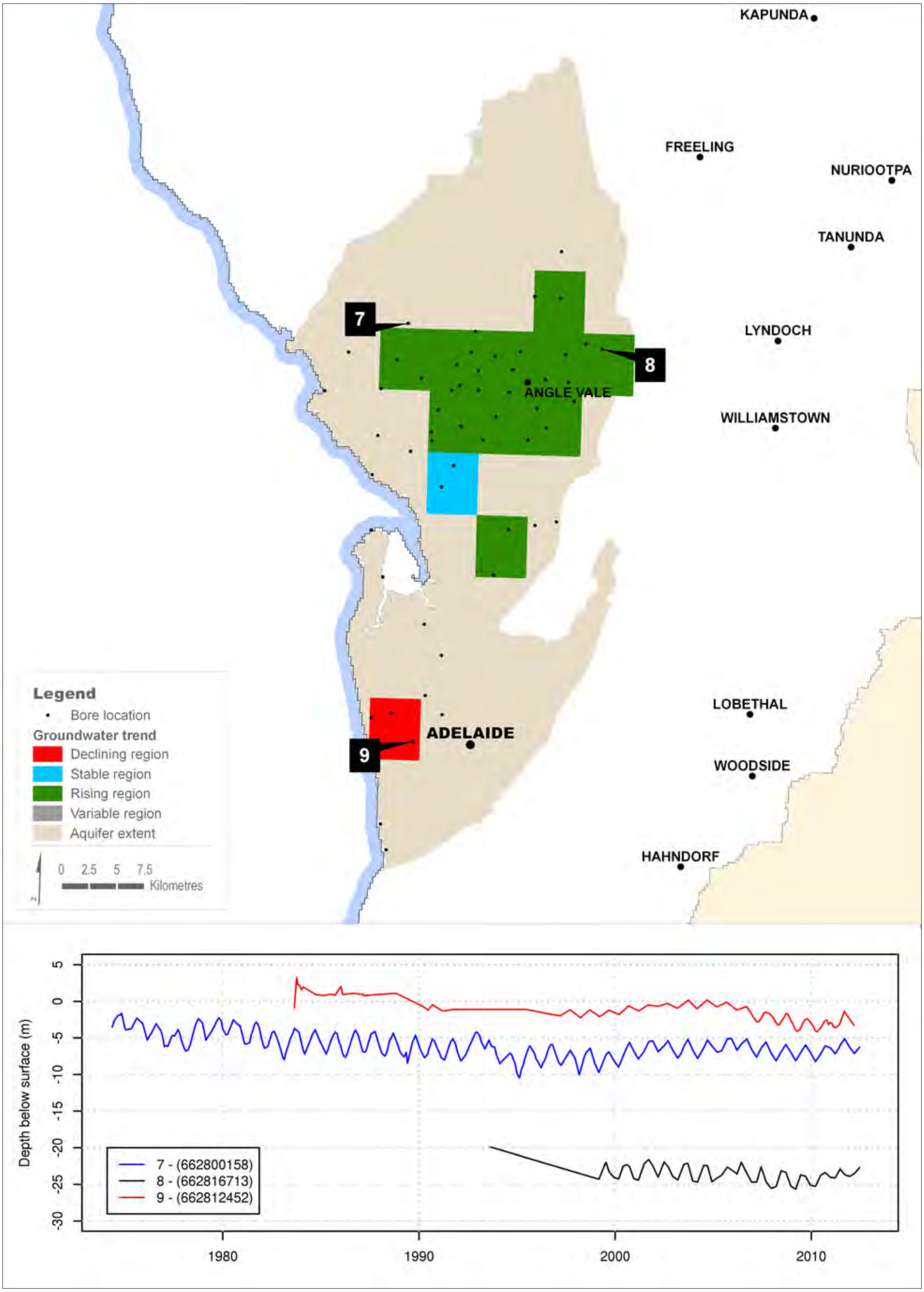



Figure 8.33 Spatial distribution of trends in groundwater levels for the Adelaide Plains T2 aquifer in the South Australian Gulf region for 2007–08 to 2011–12, with selected hydrographs showing groundwater levels

## McLaren Vale aquifers

Figure 8.34 illustrates the spatial and temporal trends in groundwater levels of the McLaren Vale watertable over the period 2007–08 to 2011–12. Grid analyses of trends in groundwater levels were carried out in data-rich areas only where three or more bores were present in a grid cell. As shown in Figure 8.34, groundwater levels are consistently stable.

The selected bores 10–12 have annual fluctuations in water levels that are most likely caused by seasonal groundwater recharge to the watertable. Hydrographs for these bores illustrate long- term relatively stable trends in water levels and, in particular, no major recharge event since 2010.

Figure 8.35 shows the grid analyses of trends in groundwater levels within the underlying Willunga aquifer, illustrating stable or declining levels for the period 2007–08 to 2011–12.This is a highly utilised aquifer and therefore the declining trends are most likely driven by groundwater extraction.

The selected bores 13–15 show continuously declining levels since the start of the records, with annual fluctuations in groundwater levels that correspond to seasonal cycles of pumping and recovery.

Figure 8.36 shows the grid analyses of trends in groundwater levels within the Maslin aquifer, indicating no prevalent trend over the period 2007–08 to 2011–12; however, no grid cells with an overall declining trend are present. This aquifer becomes unconfined in the northeast; therefore the groundwater level trends are likely to reflect the recent groundwater recharge episodes due to high rainfall.

Bores 16, 17 and 18 located at the eastern and southern ends of the Maslin Sands aquifer have stable water levels for the period 2007–08 to 2011–12 with no major recharge episode post 2010. Bore 17, located at the western end of the aquifer, shows annual fluctuations in water level that may be due to pumping from a nearby bore.

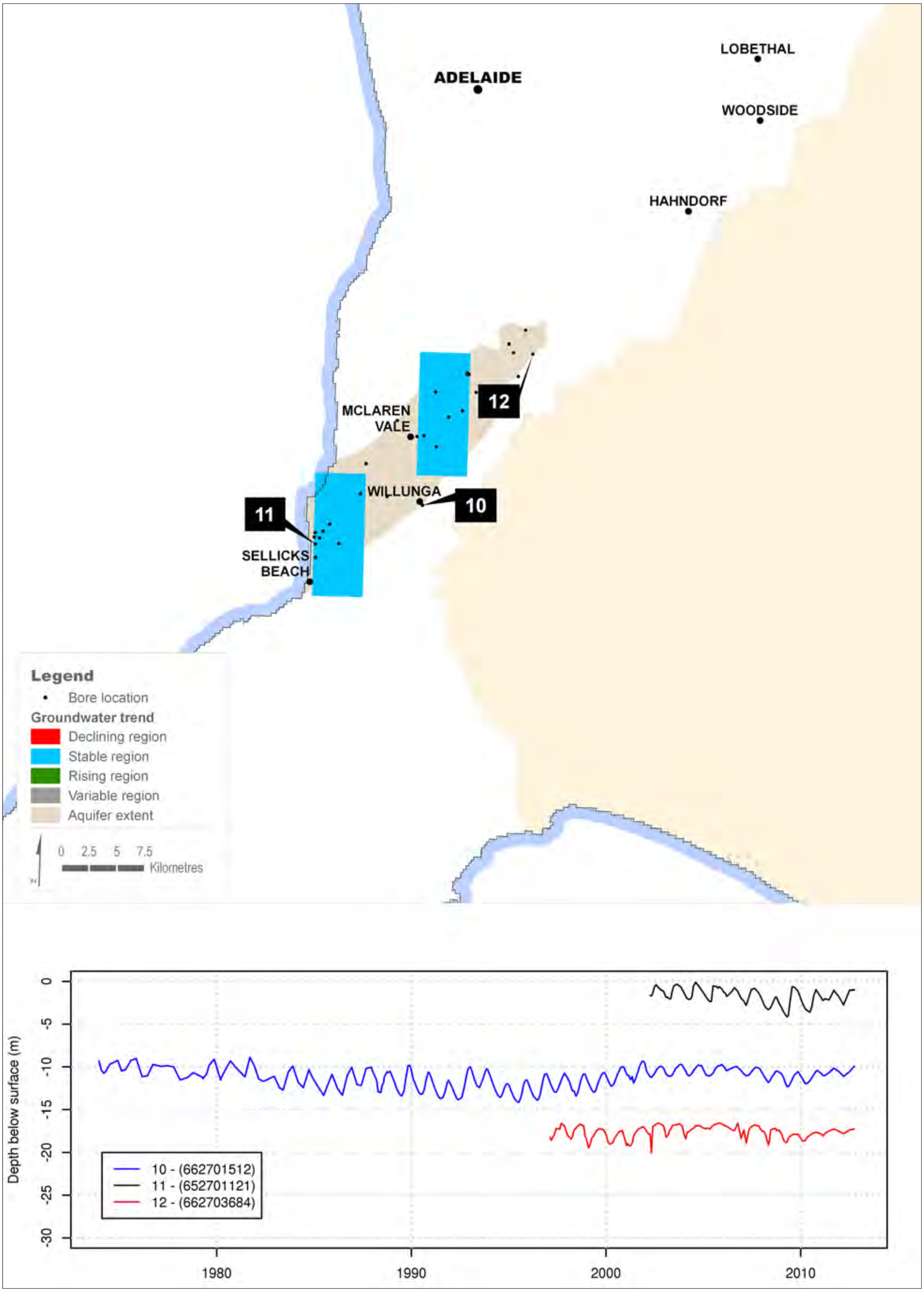



Figure 8.34 Spatial distribution of trends in groundwater levels for the McLaren Vale watertable in the South Australian Gulf region for 2007–08 to 2011–12, with selected hydrographs showing groundwater levels

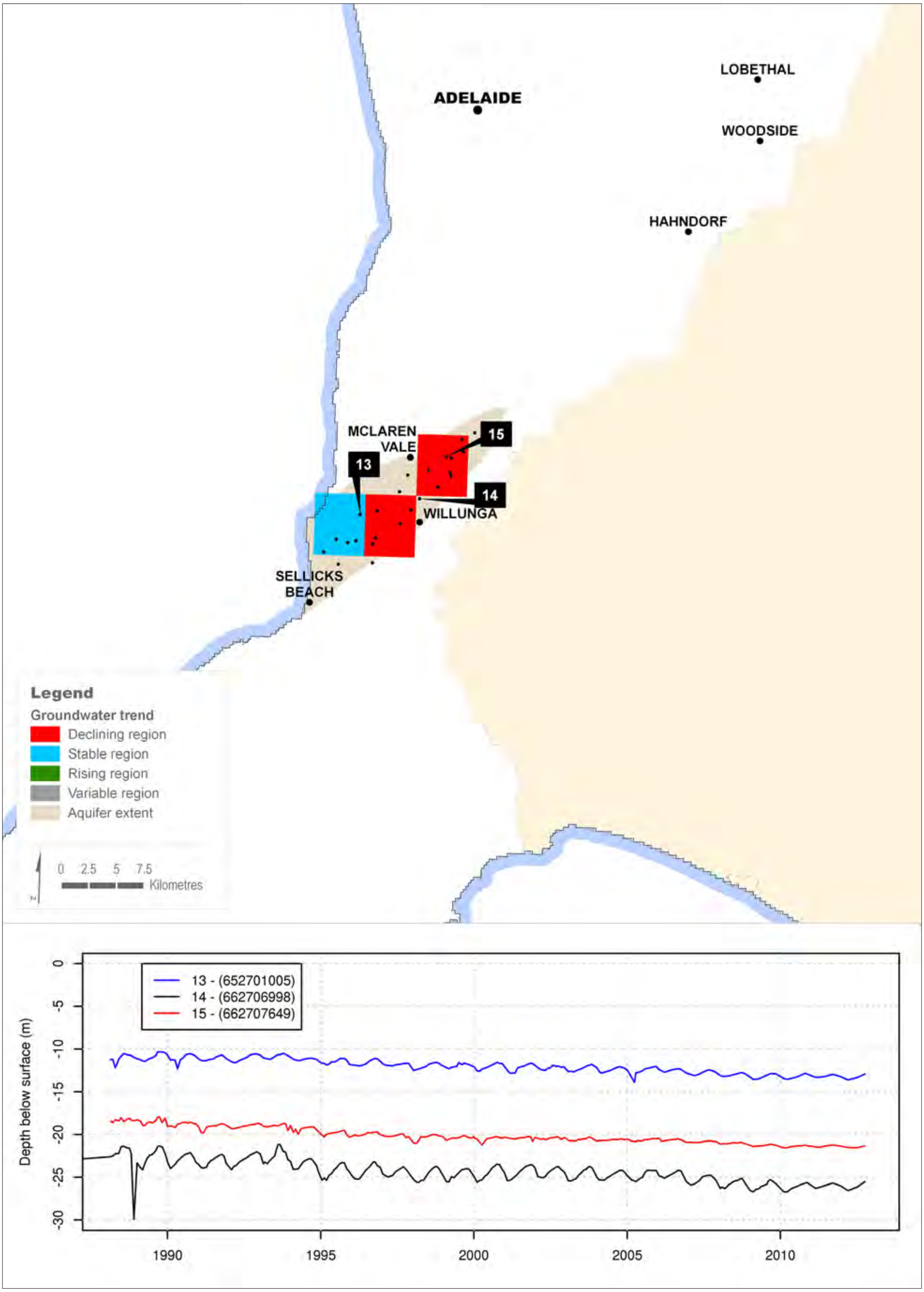



Figure 8.35 Spatial distribution of trends in groundwater levels for the Port Willunga aquifer in the South Australian Gulf region for 2007–08 to 2011–12, with selected hydrographs showing groundwater levels

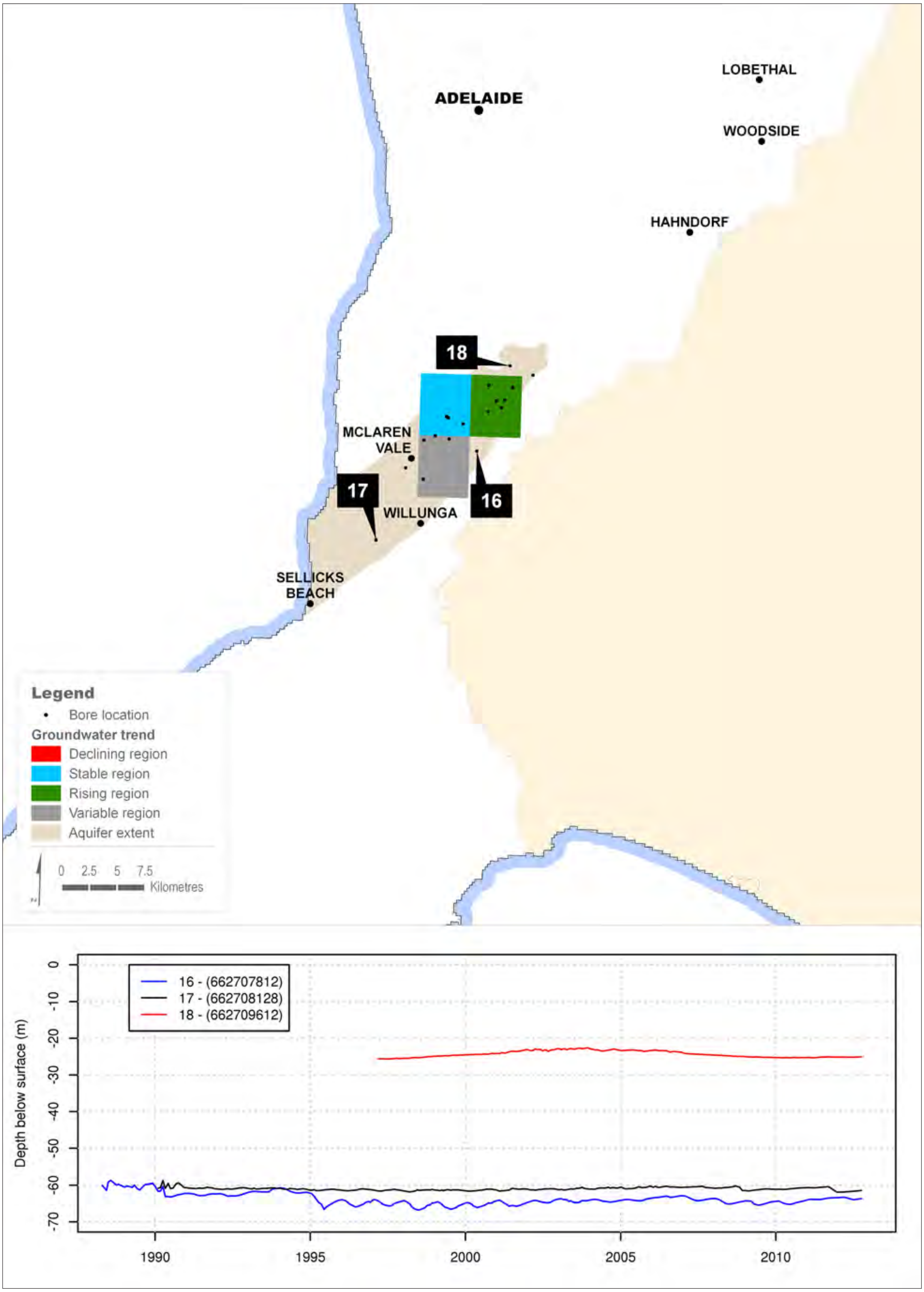



Figure 8.36 Spatial distribution of trends in groundwater levels for the Maslin Sands aquifer in the South Australian Gulf region for 2007–08 to 2011–12, with selected hydrographs showing groundwater levels

## 8.6 Water for cities and towns

This section examines the urban water situation in the South Australian Gulf region in 2011–12. The large urban centres in the region, their water supply systems and storage situations are briefly described. The main urbanised area, Adelaide, is discussed in more detail in subsection 8.6.3, including the history of water restrictions over recent years.

### 8.6.1 Urban centres

Adelaide is the largest city in the South Australian Gulf region and has more than 1.1 million residents. It is located north of the Fleurieu Peninsula, on the Adelaide Plains between the Gulf of St Vincent and the low-lying Mount Lofty Ranges which surround the city. Adelaide stretches 20 km from the coast to the foothills, and 90 km from Gawler at its northern extent to Sellicks Beach in the south.

Beyond Adelaide the region has four major population centres: Whyalla, Port Lincoln, Port Augusta and Port Pirie. These urban centres, along with Adelaide and other regional towns in conjunction with their population ranges, are shown in Figure 8.37.

The major urban centres of the region (populations over 10,000 people) are also summarised in Table 8.3. This table provides information on the population, surrounding river basins and significant water storages for each of the major centres.

Whyalla, with a population of just under 22,000, is the region's second most populous city. It is a seaport located on the northeast coast of the Eyre Peninsula. The town is strongly influenced by the mining industry.

Port Lincoln is the third major town in the South Australia Gulf region and has a population of just over 14,000. It is a seaside town on Boston Bay at the southern extremity of the Eyre Peninsula. It is the largest town in the west of the region, and is located approximately 650 km from Adelaide.

Port Augusta has a population of just fewer than 14,000 and is the region's fifth most populous town. It is a seaport and railway junction at the northern tip of the Spencer Gulf.

The population of Port Pirie is 13,800. It is also a seaport on the east coast of the Spencer Gulf, about 225 km north of Adelaide.

Table 8.3 Cities and their water supply sources in the South Australian Gulf region

| City | Population[1] | River basin | Major supply sources |
|---|---|---|---|
| Adelaide | 1,104,000 | Gawler, Torrens, Onkaparinga, Myponga and Fleurieu Peninsula | Myponga, Barossa, Little Para, Kangaroo Creek, Mount Bold, Happy Valley, Hope Valley, Warren, Millbrook and South Para storages |
| Whyalla | 21,700 | Spencer Gulf | River Murray (Morgan–Whyalla pipeline) |
| Port Lincoln | 14,100 | Eyre Peninsula | Groundwater (Southern Basins)<br>River Murray (Morgan–Whyalla pipeline) |
| Port Pirie | 13,800 | Mambray Coast and Broughton River | Baroota storage, River Murray (Morgan–Whyalla pipeline) |
| Port Augusta | 13,500 | Mambray Coast | River Murray (Morgan–Whyalla pipeline) |

[1] Australian Bureau of Statistics (2011b)

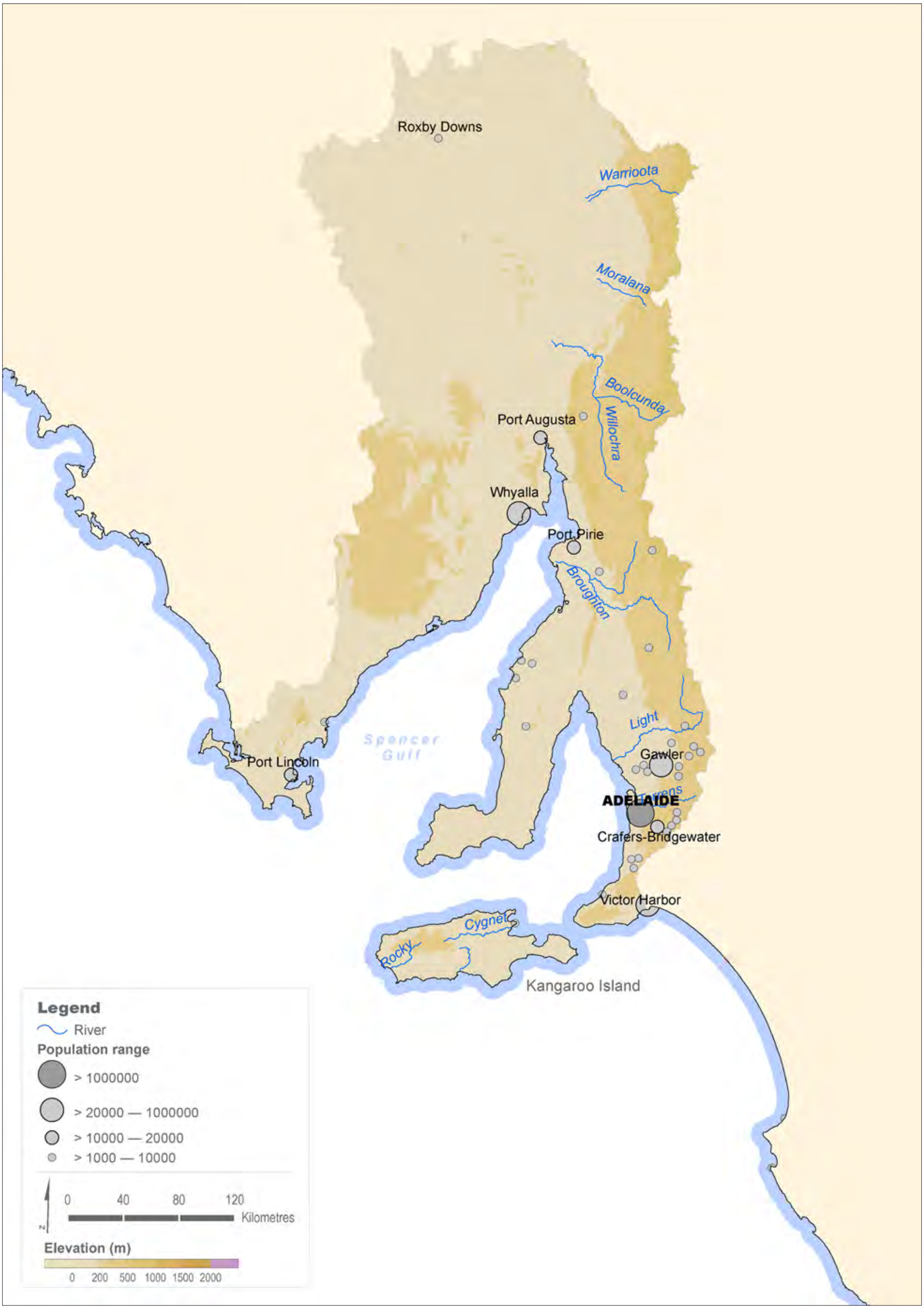



Figure 8.37 Population range of urban centres in the South Australian Gulf region

## 8.6.2 Sources of water supply

While the regions's surface water storages play an important role in the provision of its water supplies, its relatively low rainfall and long, dry summers have seen a growth in its dependence on diversions from the River Murray to meet its demands. South Australia holds an 1,850 GL-per-year entitlement to flows in the River Murray and during good rainfall years is entitled to extract an additional 3 GL per day as dilution flows.

Flows extracted from the Murray are distributed throughout the region by five bulk water transfer pipelines totalling over 650 km in length.

The Mannum–Adelaide and the Murray Bridge–Onkaparinga pipelines supply the city of Adelaide while the Swan Reach–Stockwell pipeline supplies water to townships (and farms) north of Adelaide and along its route.

The Morgan–Whyalla pipeline supplies many of the regions northern population centres and rural communities, including those of Whyalla, and Port Augusta to Woomera. At a length of 379 km, it is the longest of the five major pipelines in the region. Communities in the upper southeast of the region are supplied via the Tailem Bend–Keith pipeline. Figure 8.38 shows the major pipelines and storages in use for urban water supply.

In addition to imported and surface water storages, the region relies heavily on groundwater, recycled water and harvested storm and rainwater to supply its urban demands. In particular, South Australia has been a national leader in the use of recycled and stormwater.

## 8.6.3 Adelaide

The South Australia Water Corporation (SA Water) is the South Australian Government-owned statutory body that owns and manages Adelaide's water supply systems, recycled water systems and wastewater services. SA Water controls surface water diversions, operates water treatment plants and maintains Adelaide's reticulation system.

It supplies customers in the greater Adelaide area which includes the city of Adelaide as well as the surrounding suburbs, stretching over the Gawler, Torrens, Onkaparinga and Myponga river basins.

### Water supply system

Historically, the provision of a reliable and secure water supply to Adelaide has been a challenge because of its highly variable rainfall; however, the construction of a series of major pipelines supplying water from the River Murray and construction of a desalination plant have served to further ensure a reliable water supply for Adelaide.

Key components of the Adelaide water supply system include the Mannum–Adelaide and Murray Bridge–Onkaparinga pipelines, ten major storages totalling 197 GL in capacity, seven water treatment plants and twelve wastewater treatment plants. In addition, a number of privately operated bore fields supply groundwater primarily for agricultural uses. Some treated water is exported to adjacent regions for urban consumption.

The Mannum–Adelaide pipeline was the first of the pipelines built to deliver River Murray water to Adelaide. It supplies water to the Anstey Hill water treatment plant and to a number of storages.

The Murray Bridge–Onkaparinga pipeline was completed in 1973 and supplies water to the Summit Storage water treatment plant as well as releasing water into the Onkaparinga River for collection and treatment downstream.

Development of the Port Stanvac desalination plant was staged by constructing two 50 GL per year capacity plants. The first plant started production in October 2011 and the second during late 2012. Water from the desalination plant is mixed with treated surface water from the Happy Valley water treatment plant and discharged directly into Adelaide's distribution system.

SA Water operates a number of recycled water and stormwater harvesting schemes. It also strongly promotes individual use of rainwater across the region. A number of recycled water schemes that supply treated effluent for agricultural and municipal irrigation and residential use operate within the greater Adelaide area. Several community or privately operated recycling schemes supply to viticulture and municipal applications.


Figure 8.38 Water supply systems in the South Australian Gulf region

## Storage volumes

The Mount Bold, South Para, Kangaroo Creek and Myponga storages constitute 69% of the total Adelaide system storage. South Para serves the Northern Adelaide Plains. Kangaroo Creek is used to supply water to the northern Adelaide suburbs from Port Adelaide to the Torrens River while Mount Bold serves the southern Adelaide suburbs from the Torrens River to the Onkaparinga River. Water from Myponga is distributed along the coast from the Onkaparinga River to Normanville. The accessible volumes of these major storages are shown individually in Figure 8.39.

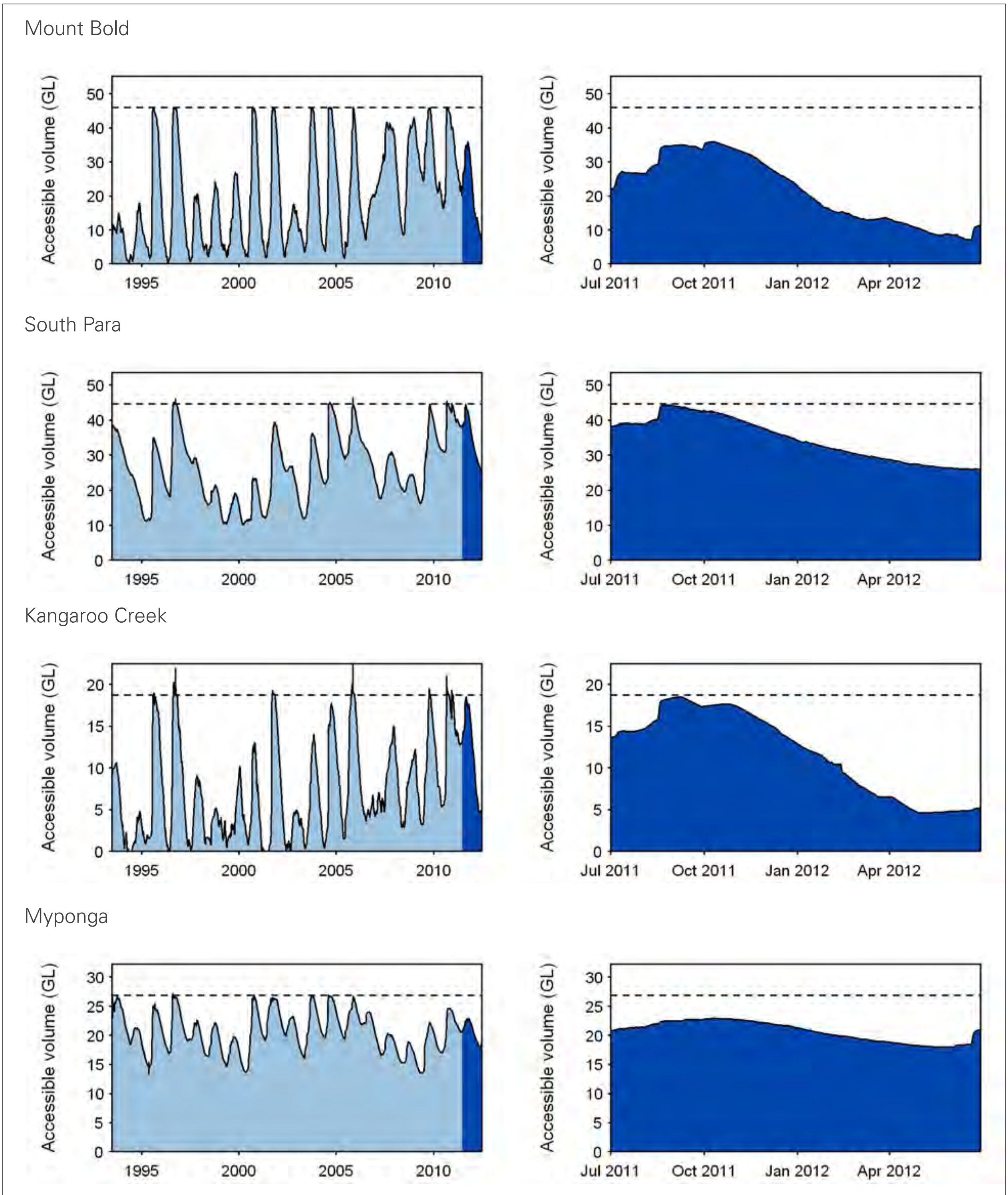



Figure 8.39 Variation in the amount of water held in storage over recent years (light blue) and over 2011–12 (dark blue) for Mount Bold, South Para, Kangaroo Creek and Myponga storages, as well as total accessible storage capacity (dashed line)

Mount Bold is the largest storage, with a capacity of 46 GL, and it contributes approximately 20% of the total storage capacity.

The large annual fluctuation of the accessible storage shown in these figures illustrates the highly variable nature of Adelaide's surface water resources. The figures highlight the general trend of filling during July–October and their drawdown across the drier summer period.

Extractions from the River Murray are highly dependent on the inflows to storages from their surrounding catchments. Extractions can range from 40% of the total water sourced in high rainfall years to 90% in years of very low rainfall.

### Water restrictions

Water restriction in Adelaide and in most of the region are set by the State Government and enforced by SA Water. Restriction triggers are not solely based on the total available water in storage. Water restrictions in Adelaide are instead dependent on flows from the Mount Lofty Ranges and also on conditions in the Murray–Darling Basin, including volumes in the Hume and Dartmouth storages.

Restrictions applied to Adelaide outdoor water consumption are shown against combined storage volumes of Mount Bold, South Para, Kangaroo Creek and Myponga in Figure 8.40.

In the early 2000s, local storages, catchments and the River Murray were stressed as a result of drought conditions within the region and the Murray–Darling Basin. This saw Level 2 water restrictions introduced in July 2003 for four months. Permanent water conservation measures (PWCM) were introduced in October 2003, promoting long-term water conservation.

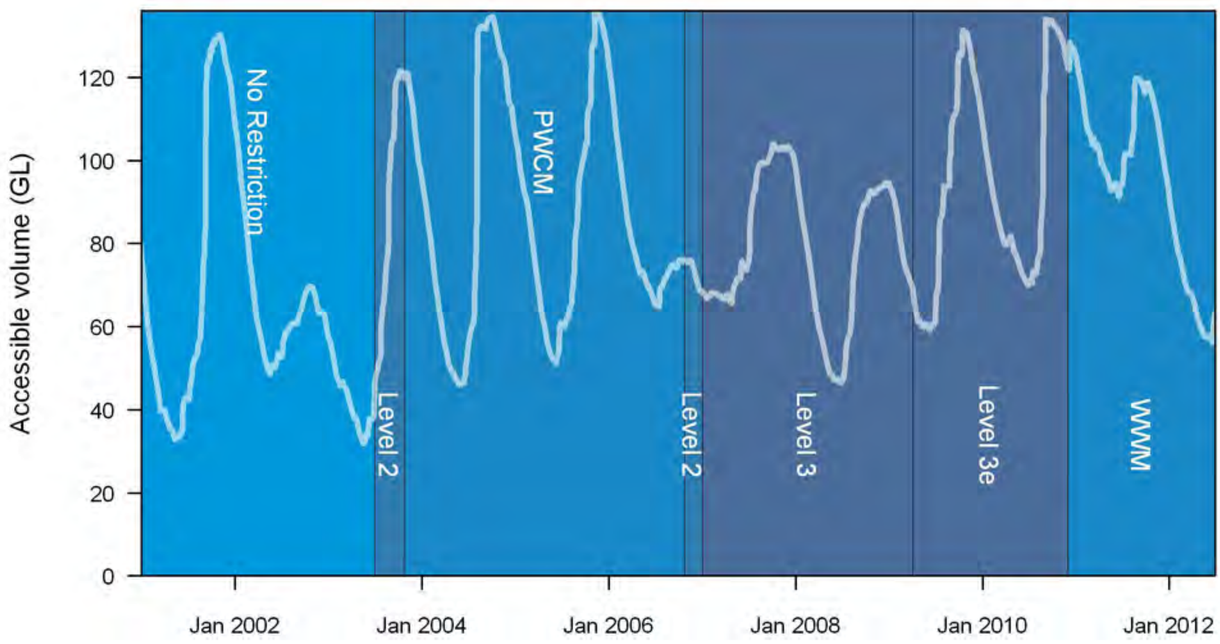



Figure 8.40 Urban water restriction levels across Adelaide since 2001 shown against the combined accessible water volume of Mount Bold, South Para, Kangaroo Creek and Myponga storages

Enhanced level 2 restrictions were introduced in October 2006, after a record dry winter and record low inflows into the River Murray. They were quickly replaced in January 2007 by Level 3 restrictions and average annual residential water use decreased from 235 to 180 kL/property in 2006–07 to 2010–11 respectively.

An easing in water restriction levels in 2011–12 has been in part attributed to a rise in the average annual domestic water consumption of Adelaide, increasing to 195 kL/property (National Water Commission 2012).The South Australian Government imposed a temporary cessation on all outdoor watering in July 2007 which was extended through to August and September due to low winter flows. In October 2007, Adelaide residents were permitted to water for three hours per week; this was increased to five hours and then seven hours in April and May 2010 respectively.

Permanent water wise measures (WWM) were introduced on 1 December 2010 to cement water conservation across the region and to include measures to manage domestic and commercial water use.

### Sources of water obtained

Figure 8.41 shows the total volume of water sourced from surface water, recycled and desalination water for supply to Adelaide (National Water Commission 2012). Demand management and water conservation measures have seen a continuing decline in the total water sourced by SA Water.

Between 2006–07 and 2011–12, the highest volume of total water sourced was 181 GL in 2006–07, which was a very dry and hot year. Over the following three years, the volume of water sourced was lower and constant as a result of demand management through water restrictions.

In 2011–12, recycled water comprised 3% of the total water sourced for Adelaide. A further 3% was sourced from desalinated water. For the remaining years shown in Figure 8.41, approximately 15% of the total water sourced was recycled water.

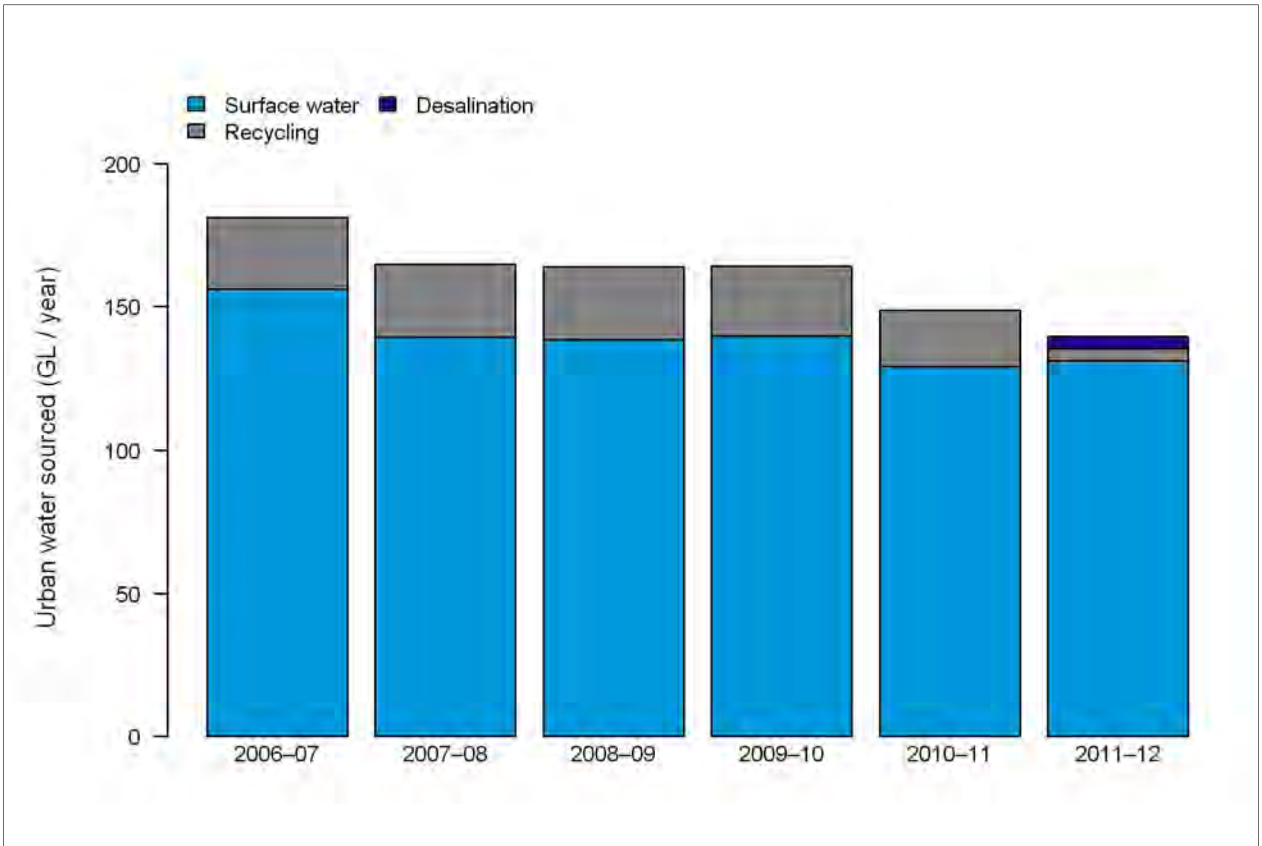



Figure 8.41 Total urban water sourced for Adelaide from 2006–07 to 2011–12

## Categories of water delivered

Figure 8.42 shows the total volume of water delivered to residential, commercial, municipal, industrial and other consumers in Adelaide from 2006–07 to 2011–12. Water supply data of the last six years has been obtained from the National Water Commission's National Performance Reports (National Water Commission 2013).

Water supply has steadily decreased from 2006–07 to 2010–11. The consumption of water increased in 2011–12 due to the lower water restrictions and above average rainfall in the region. Residential water use constitutes between 66% and 75% of Adelaide's total water consumption. The maximum residential water use in Adelaide was during the year 2006–07 when more than 115 GL were supplied for residential use. As discussed above, water restrictions and conservation measures subsequently had a marked influence on residential water use.

The Level 2 and Level 3 restrictions introduced in 2006–07 reduced annual residential consumption to an average of 93 GL over the period 2007–08 to 2010–11. The average commercial, municipal and industrial water consumption in Adelaide during 2006–07 to 2011–12 was about 28 GL, with a maximum of more than 35 GL in 2006–07. By 2011–12, consumption by the commercial, municipal and industrial sectors fell to 26 GL with the lowest at 16 GL in 2009–10, almost half of the 2006–07 consumption.

Based on the data obtained from the National Performance Reports, the average water supply per property for residential use in Adelaide from 2006–07 to 2011–12 was estimated to be 195 kL. The maximum annual residential water use per property was 235 kL in 2006–07 and the minimum was 180 kL in 2010–11.

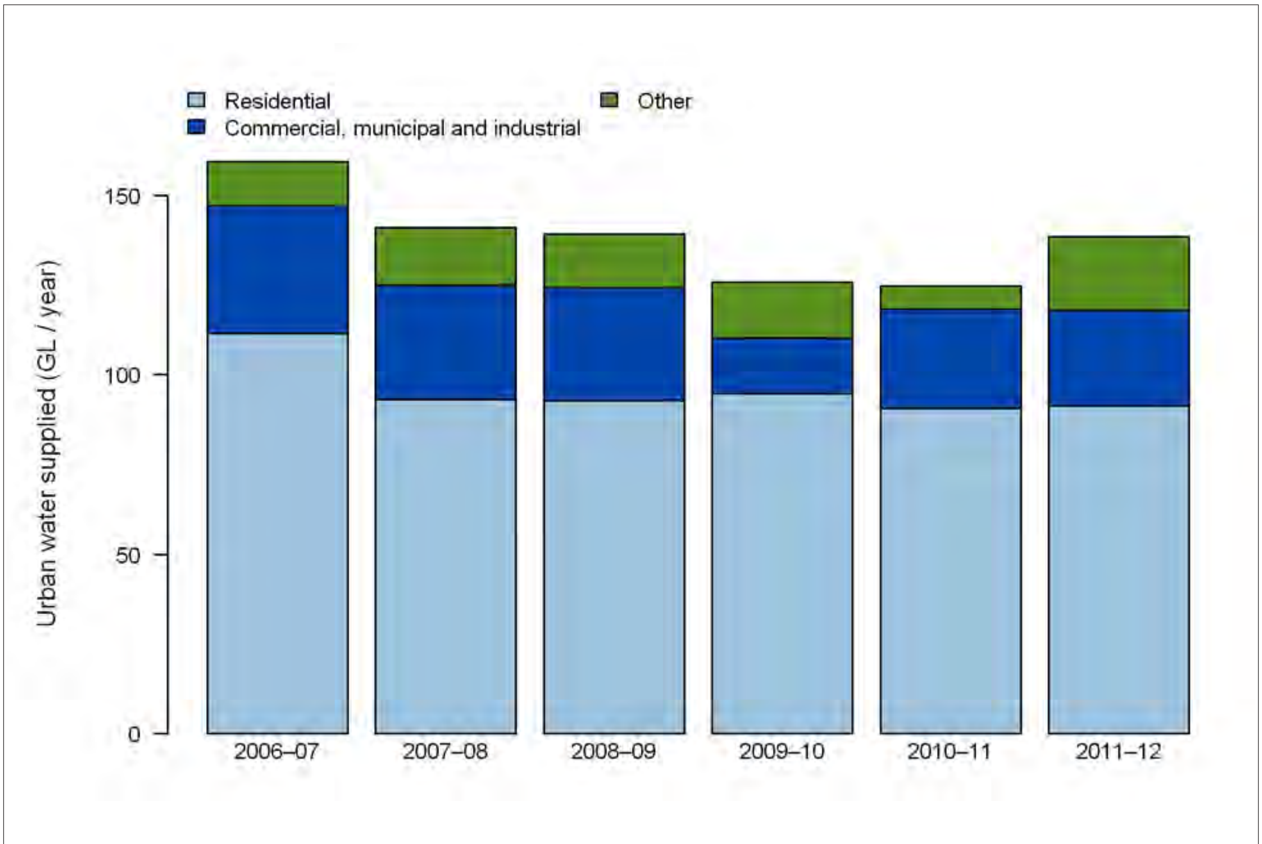



Figure 8.42 Categories of water delivered to Adelaide from 2006–07 to 2011–12

## 8.7 Water for agriculture

This section describes the water situation for agriculture in the South Australian Gulf region during the 2011–12 year compared with the past. Modelled soil moisture conditions are presented and important irrigation areas are identified. The McLaren Vale Irrigation Area is described in more detail.

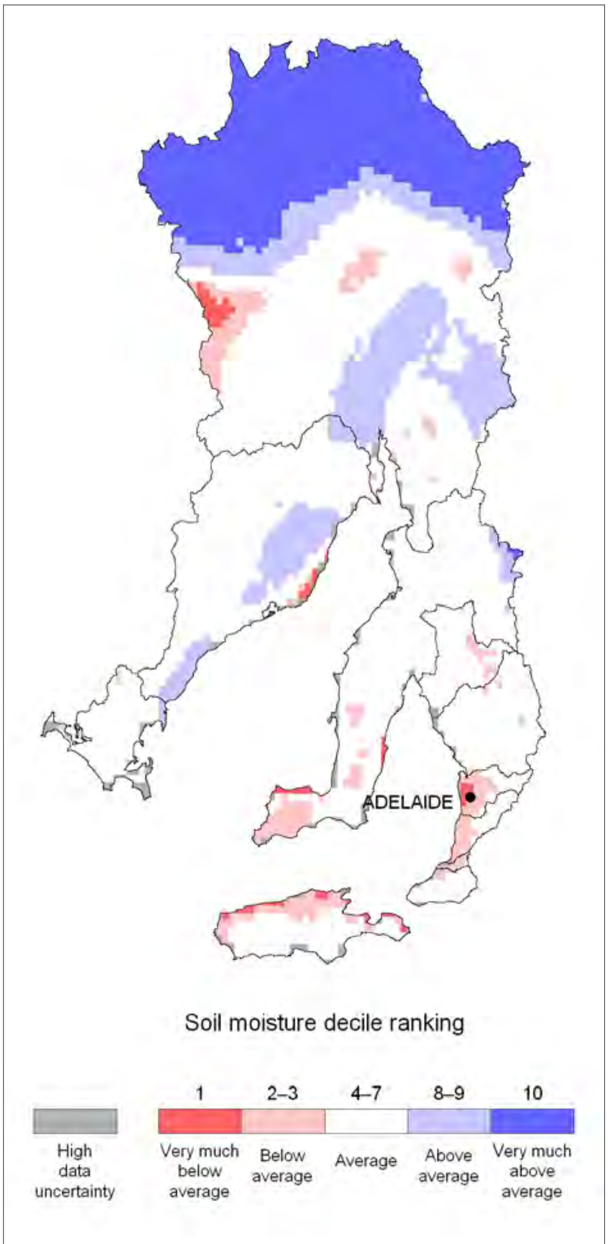



Figure 8.43 Deciles rankings of annual average soil moisture for 2011–12 with respect to the 1911–2012 period for the South Australian Gulf region

### 8.7.1 Soil moisture

Since model estimates of soil moisture storage volumes are based on a simple conceptual representation of soil water storage and transfer processes averaged over a 5 km x 5 km grid cell, they are not suitable for comparison with locally measured soil moisture volumes. This analysis therefore presents a relative comparison only, identifying how modelled soil moisture volumes of 2011–12 relate to modelled soil moisture volumes of the 1911–2012 period, expressed in decile rankings.

Except for a narrow strip in the northern pastoral lands which had high above average soil moisture conditions, the South Australian Gulf region experienced average conditions (Figure 8.43). This follows the rainfall decile ranking during 2011–12 in the region. The similarity is more distinct for the northern and southern parts of the region.

Some irrigated lands of the southern region experienced below to very much below average soil moisture conditions (Figure 8.43).

Decile ranking of the changes in soil moisture averaged over the whole region during 2011–12 year indicates marginally above average conditions that rose in March due to historically high rainfall events, and continued during the autumn period (Figure 8.44).

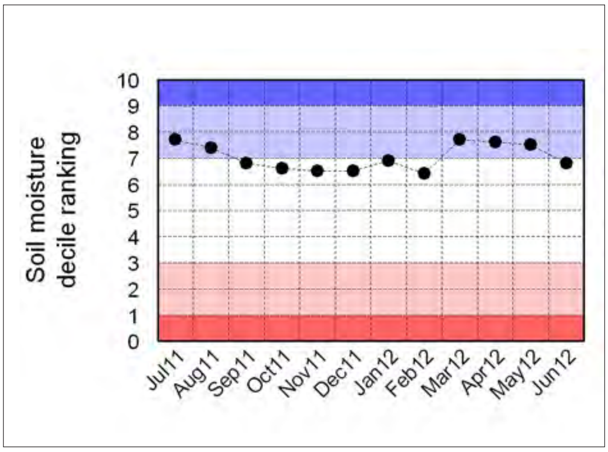



Figure 8.44 Decile ranking of the monthly soil moisture conditions during the 2011–12 period in the South Australia Gulf region

### 8.7.2 Irrigation water

A comparison of annual irrigation water use in parts of the region for the period between 2005–06 and 2010–11 is shown by natural resource management (NRM) regions in Figure 8.45. Figure 8.46 shows the variation in annual water use between the two NRM regions in the South Australian Gulf region during 2010–11 year.

Data for the 2011–12 year was not available at the time of preparation of this report.

The McLaren Vale prescribed wells area in the Onkaparinga catchment is described in the following section as an example of irrigated agriculture water use in the region.

### 8.7.3 Irrigation areas

Dryland agriculture is the main agricultural activity in the South Australian Gulf region apart from grazing pasture. Viticulture and wine grape production is the main irrigated agriculture mostly in the Onkaparinga catchment (Figure 8.47). Water for these enterprises is sourced from the Mount Lofty Ranges and River Murray diversions. Mount Bold on the Onkaparinga River is the largest storage in the region with an accessible storage capacity of 46 GL.

In most years, inflows to storage are supplemented by water pumped from the River Murray via a pipeline from Murray Bridge. The majority of irrigated water use occurs in the south-eastern areas where viticulture is concentrated.

The McLaren Vale prescribed wells area is described in more detail in section 8.7.4 below.

### 8.7.4 McLaren Vale prescribed wells area

The McLaren Vale prescribed wells area is located within the Onkaparinga catchment, 35 km south of Adelaide within the boundaries of the Western Mount Lofty Ranges prescribed area, and covers an area of 320 km$^2$.

By regulation in 1998, all existing and future wells within the area were declared to be prescribed wells. Prescription is the legal mechanism for implementing a water resource management regime in South Australia. A prescribed water resource is managed through an allocation and licensing system.

The area was formed after amalgamating the Willunga Basin prescribed wells area and the Upper Willunga catchment moratorium area in 2000. The climate of the area is Mediterranean, with cool, wet winters and hot, dry summers. Annual rainfall varies from around 400 mm to around 900 mm. Irrigated viticulture accounts for more than 85% of the irrigation in the region. Orchards and other irrigated crops account for the remainder.

There are no large surface water inflows or storages in the McLaren Vale prescribed wells area. Around 75% of water used for irrigation in the McLaren Vale prescribed wells area is sourced from groundwater. Groundwater occurs in four major aquifers: the Quaternary aquifer, Port Willunga Formation aquifer, Maslin Sands aquifer and Fractured Rock aquifer.

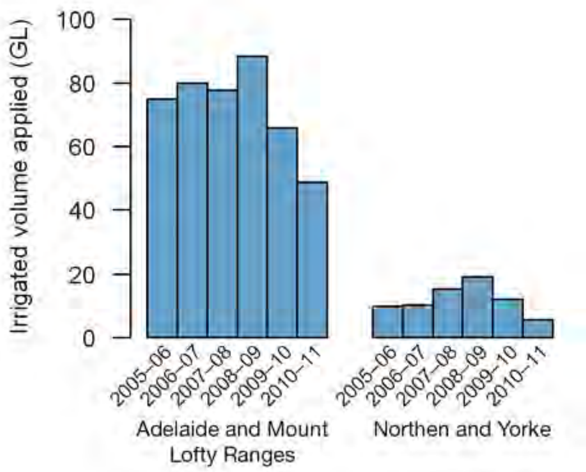



Figure 8.45 Total annual irrigation water use for 2005–06 to 2010–11 for natural resource management regions in the South Australian Gulf region (ABS 2006–2010; 2011a)

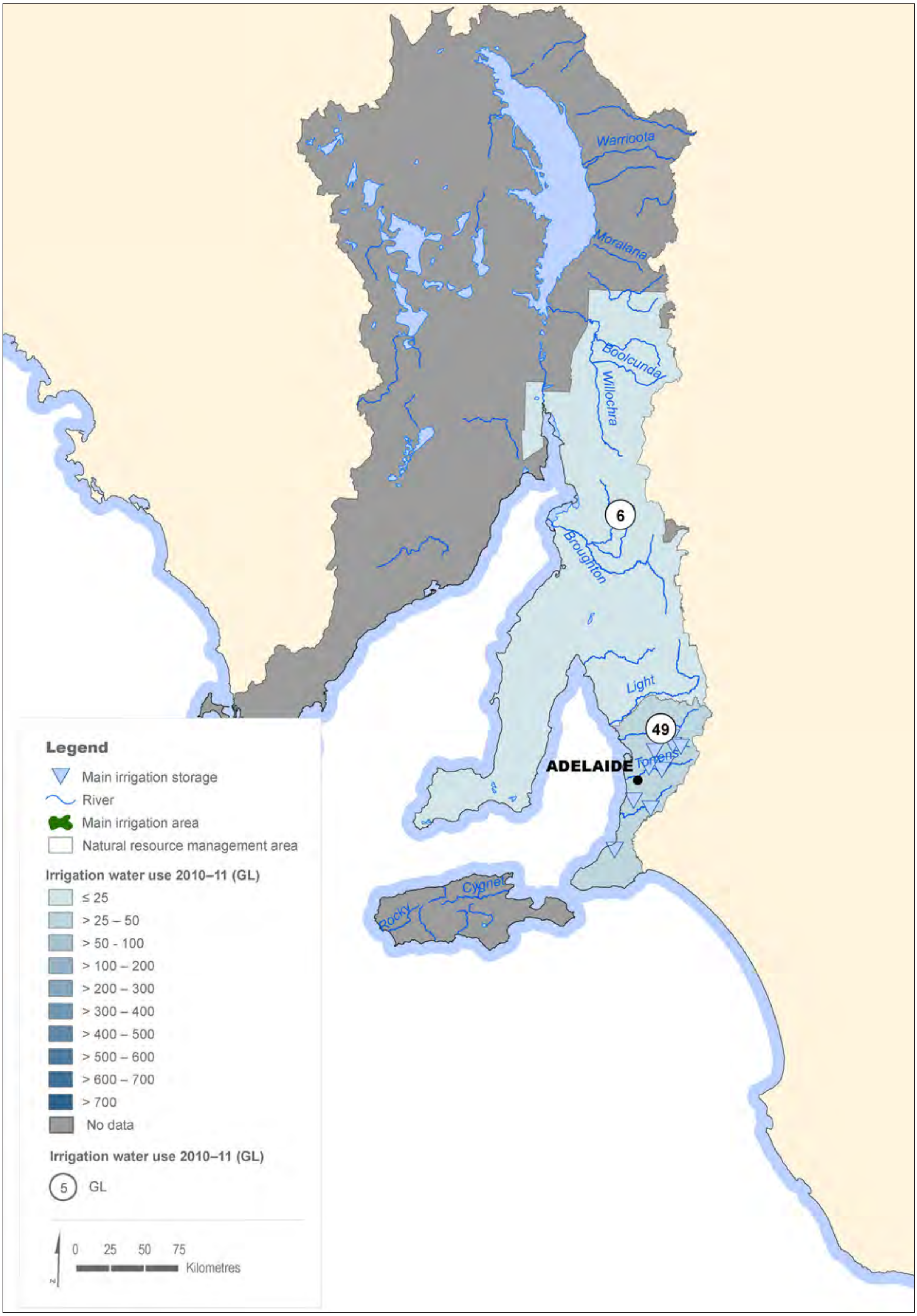



Figure 8.46 Annual irrigation water use per natural resource management region for 2010–11 (ABS 2011a)


Figure 8.47 Irrigation areas in the South Australian Gulf region

The high cost of groundwater has encouraged the development of alternative water sources such as mains water and secondary treated water from the Christies Beach wastewater treatment plant (Government of South Australia 2000).

There is an extraction limit of 6,600 ML from groundwater. Most of the water is extracted from the Port Willunga Formation aquifer. Average allocation in McLaren Vale is 1.5 ML/ha for vines and 2.8 ML/ha for other crops.

Metered groundwater extractions in the McLaren Vale prescribed wells area for 2010–11 totalled 2,529 ML, 27% less than the previous year mostly because of above average rainfall in the region near Mount Bold (Department for Water 2011). Data for the 2011–12 year was not available at the time of preparation of this report.

## Local hydrogeology

For the purpose of this report, the McLaren Vale Irrigation Area was selected as an example for the discussion of groundwater use in an irrigation area in the South Australian Gulf region.

The aquifer system in the McLaren Vale prescribed wells area (Figure 8.48) is complex but can be grouped into four aquifers listed from top to bottom: the Quaternary sediments, Willunga Formation, Maslin Sands and fractured basement rock. These aquifers are interconnected and as such, withdrawals from one aquifer will impact other aquifers. Furthermore, the aquifers are not all present at all locations in McLaren Vale.

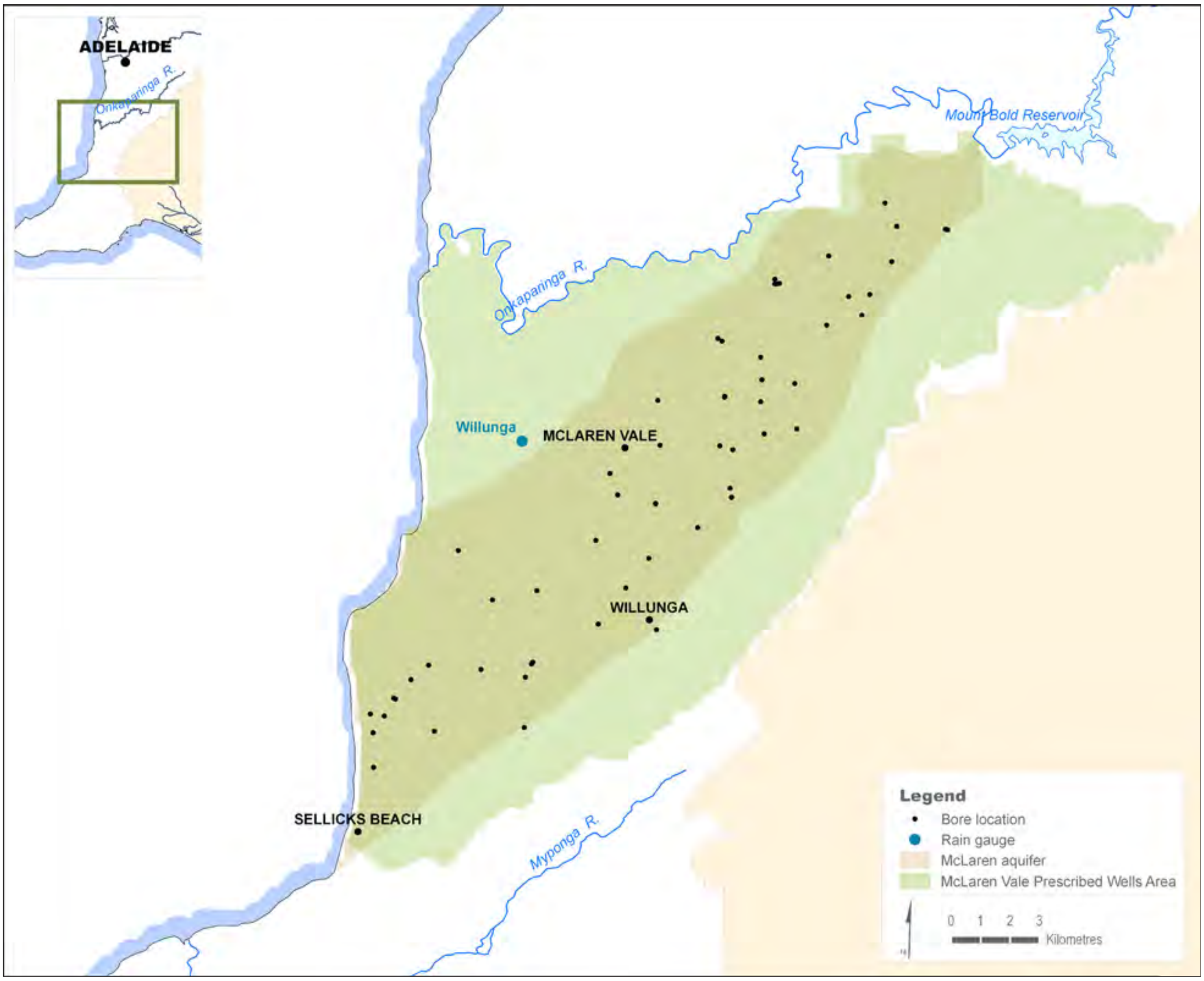



Figure 8.48 The McLaren Vale Prescribed Wells Area showing the location of groundwater bore sites and rain gauge

The Willunga aquifer supplies 64% of groundwater extracted for irrigation, with the Maslin Sands and fractured basement rock aquifers supplying 20% and 16% respectively (Australian Bureau of Agricultural and Resource Economics and Sciences 2003).

The Quaternary aquifer is generally shallow and of poor quality; however, it plays an important role in supporting groundwater-dependent ecosystems such as Aldinga Scrub and by providing base flow to creeks and streams (Department of Water, Land and Biodiversity Conservation 2007).The Willunga aquifer is the most utilised groundwater resource in McLaren Vale prescribed wells area and is comprised of sand and limestone units. The Maslin Sands aquifer overlies the Fractured Rock aquifer. The aquifer is unconfined in the northeast of the area. Like the Willunga aquifer, recharge occurs via direct rainfall infiltration in unconfined areas as well as from streams and inflow from surrounding fractured rocks.

In the McLaren Vale prescribed wells area, localised cones of depression in the groundwater level due to groundwater pumping have been identified as a potential problem, particularly for saline seawater intrusion (Martin 1998; Martin and Hodgkin 2005). Stewart (2006) reported higher salinities between McLaren Vale and Blewitt Springs than in the remainder of the aquifer. This area coincides with a deflection in the potentiometric surface for the aquifer.

### Groundwater quality overview

Groundwater salinity increases towards the coast in the Port Willunga formation aquifer. This increase of salinity down the hydraulic gradient suggests that recharge to this aquifer is limited along the groundwater flow path. The salinity of the Maslin Sands aquifer is similar to that of the Port Willunga Formation aquifer. The salinity in the Fractured Rock aquifer is variable, but generally fresh.

### Influences on shallow groundwater

There is often a very strong relationship observed in shallow aquifer systems between changes in groundwater levels and rainfall, which occur as a result of rapid recharge to these systems from rainfall (Department of Water, Land and Biodiversity Conservation 2007). Therefore, years of above average rainfall will result in rising groundwater levels, while years of below average rainfall will result in declining groundwater levels.

Fluctuations in the shallow groundwater levels were evaluated for the watertable aquifer at five selected sites using data between 1990 and 2012 (Figure 8.49). In Figure 8.49 fluctuation in groundwater levels are compared to the local monthly rainfall trend (location of rain gauge shown in Figure 8.48). Periods in which the cumulative rainfall residual mass curve rises indicate wetter than average conditions. Periods with a falling trend indicate drier than average conditions. Panel b in Figure 8.49 shows a wetter than average period up to 1994, followed by average rainfall conditions until 2006, then by a drier than average period up to 2009, and thereafter by average rainfall.

The figure illustrates that overall the groundwater response to trends in rainfall is prominent. It also shows that groundwater recharge in the watertable is driven by seasonal cycles in rainfall. All wells, except for one, show a decline in water level after 2006 and a minor recovery post 2009. This was as a result of below average rainfall conditions in the region from 2006 to 2009 followed by averaged rainfall (panel b in Figure 8.49). The pattern and magnitude of change in groundwater level is also influenced by the change in the pattern of extraction across the area.

### Groundwater level

Figure 8.50 shows ranges of groundwater depth from bores located in the three aquifers in the McLaren Vale Irrigation Area, and the ranking of 2011–12 median groundwater levels compared to annual median groundwater levels in the last 21 years (1990–2011).

As shown in Figure 8.50, typically groundwater levels in the watertable aquifer vary from very shallow 0–1 m from the surface to greater than 10 m from the surface. Median groundwater depths in 2011–12 are typically below the long-term average east of McLaren Vale town and are generally above the long-term average elsewhere.

Groundwater levels in the Willunga aquifer in 2011–12 are over all deeper than 10 m below the surface (Figure 8.51). The recorded groundwater levels are mostly below the long-term average of the past 21 years.

In the Maslin Sands (Figure 8.52), groundwater levels in 2011–12 were also generally deep (>5 m below the surface). Overall, groundwater levels in the area increased concurrent with the expansion of irrigated land. Towards the coast, groundwater levels are below the average for the last 21 years.

## Groundwater salinity

At the time of writing, suitable quality controlled and assured time-series data on groundwater salinity were not available from the Australian Water Resources Information System (Bureau of Meteorology 2011a). Therefore, groundwater salinity status of the McLaren Vale Irrigation Area has not been analysed.

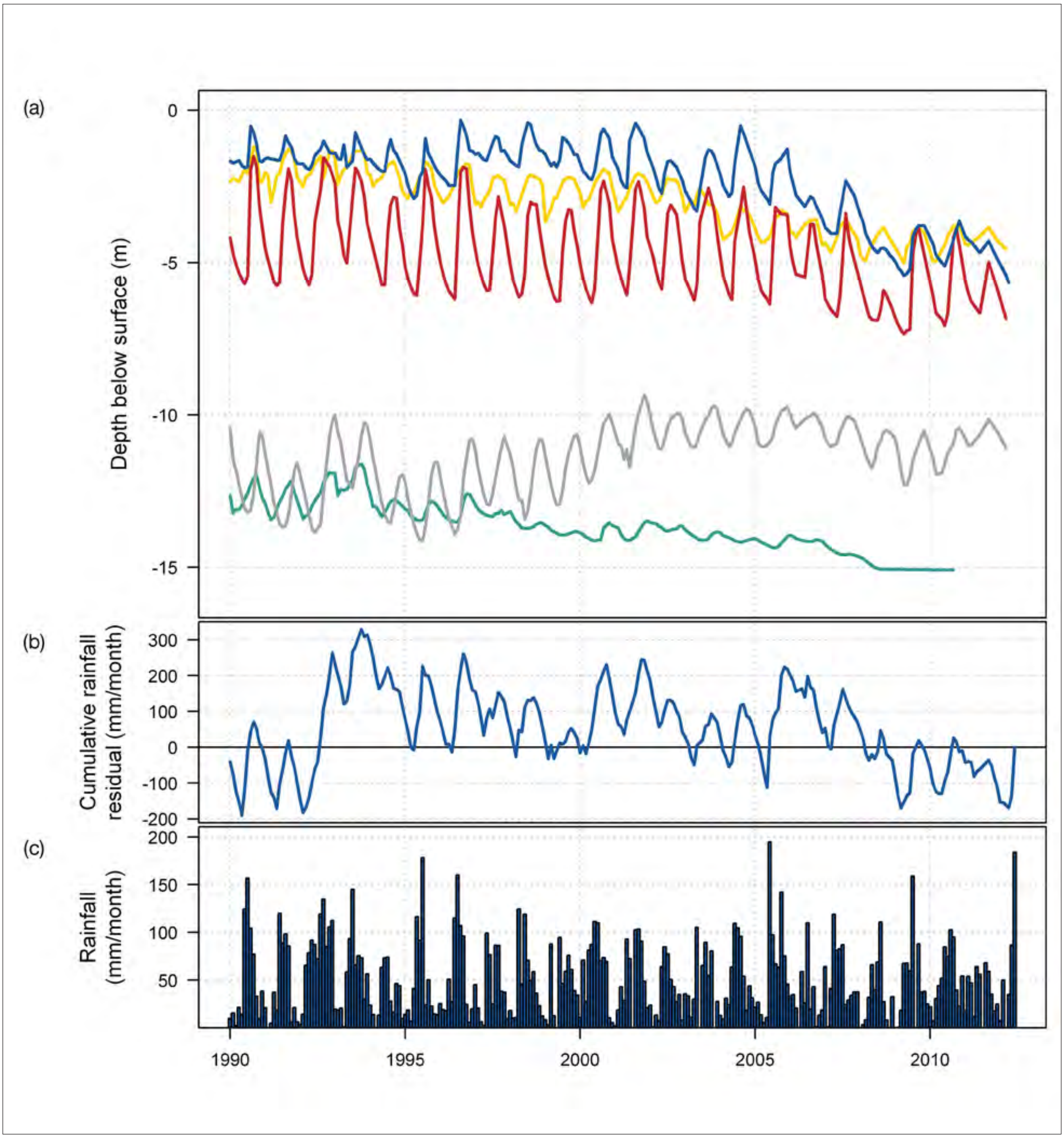



Figure 8.49 (a) Groundwater levels between 1990 and 2012 of the watertable aquifer at five bore sites in the McLaren Vale Irrigation Area, compared with (b) rainfall residuals, and (c) daily rainfall at Willunga

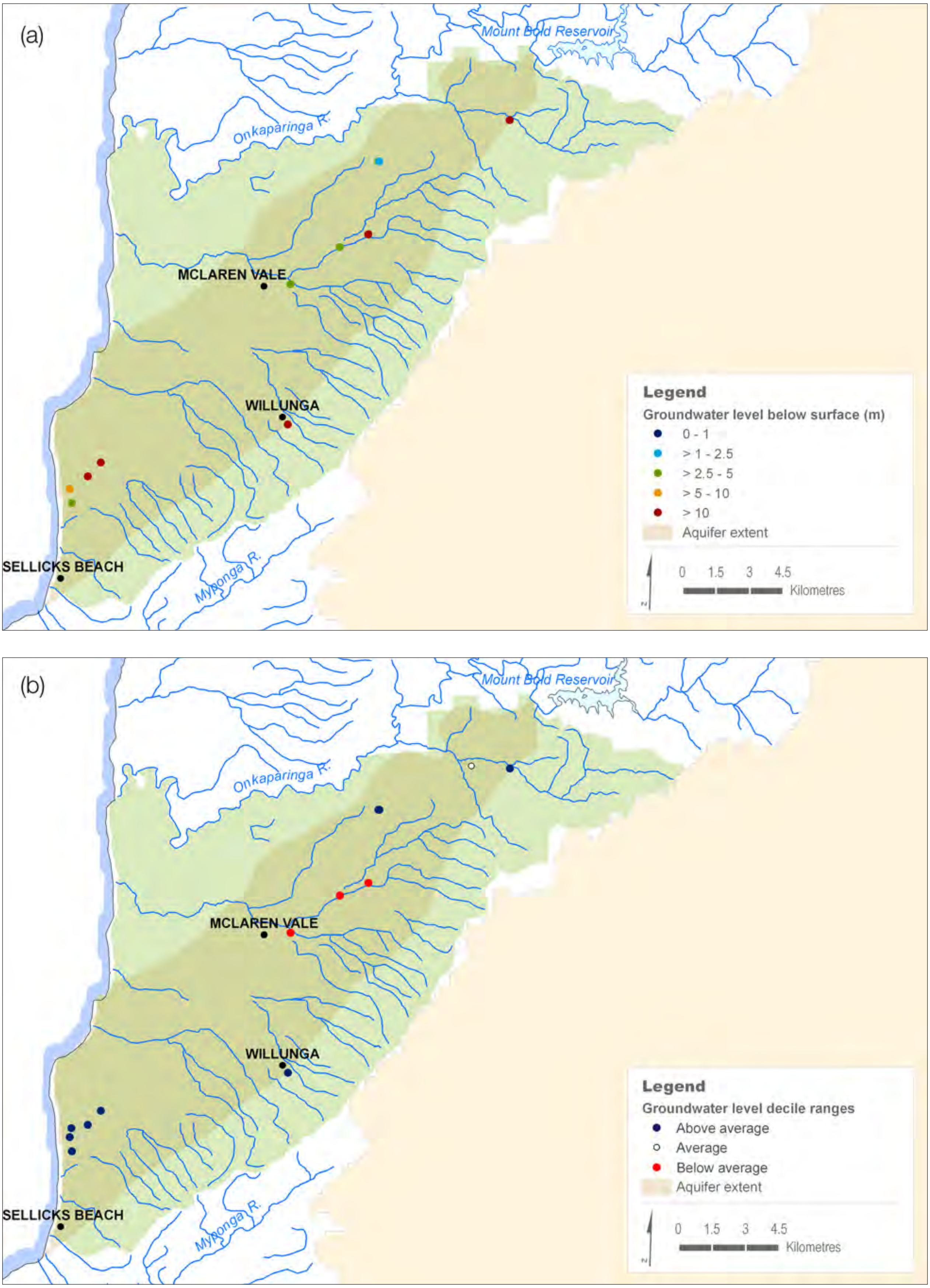



Figure 8.50 (a) Median groundwater depth below surface, and (b) groundwater level deciles in 2011–12 compared to the 1990–2012 reference period for the McLaren Vale watertable aquifer

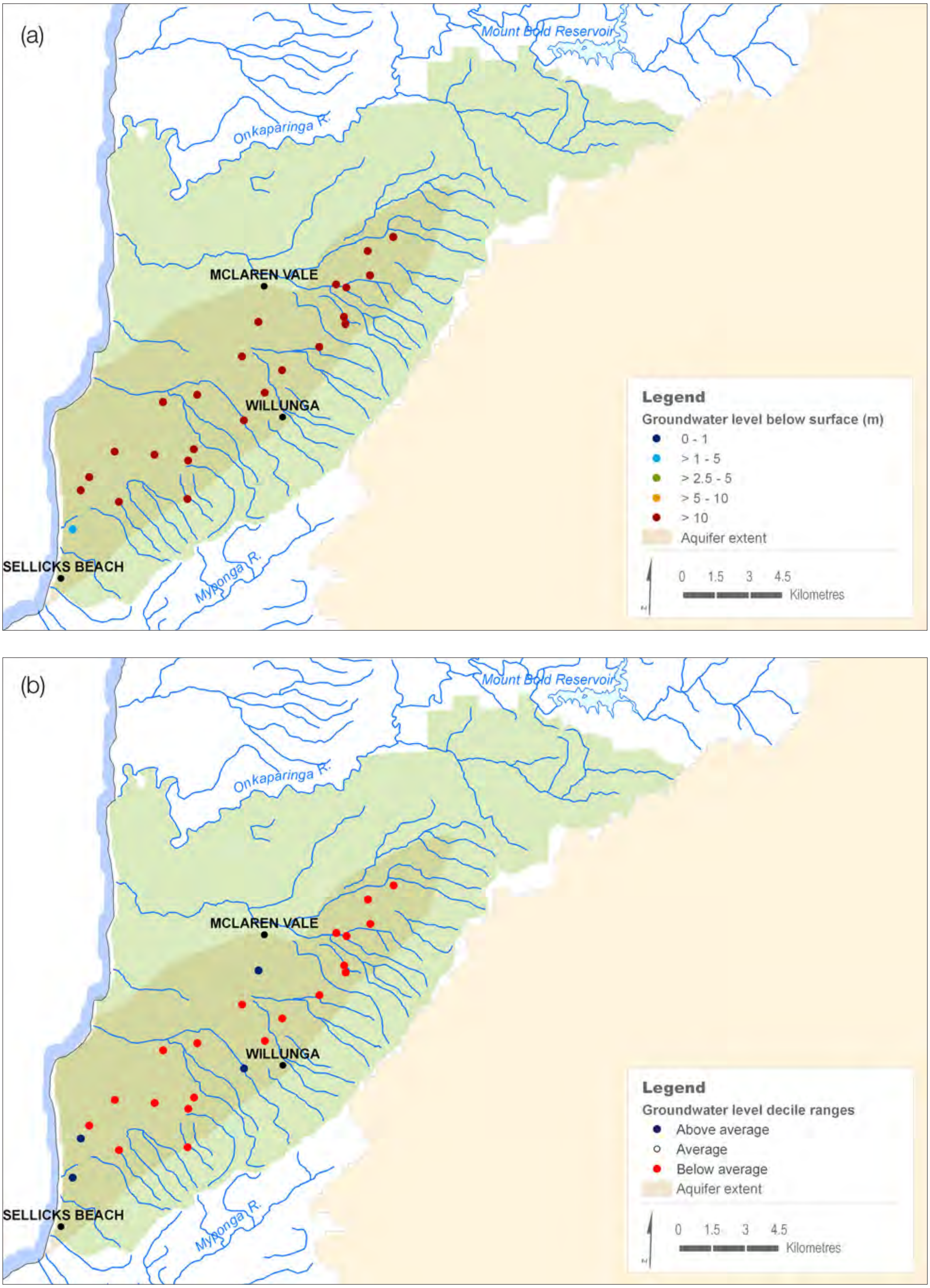



Figure 8.51 (a) Median groundwater depth below surface, and (b) groundwater levels deciles in 2011–12 compared to the 1990–2012 reference period for the Willunga aquifer

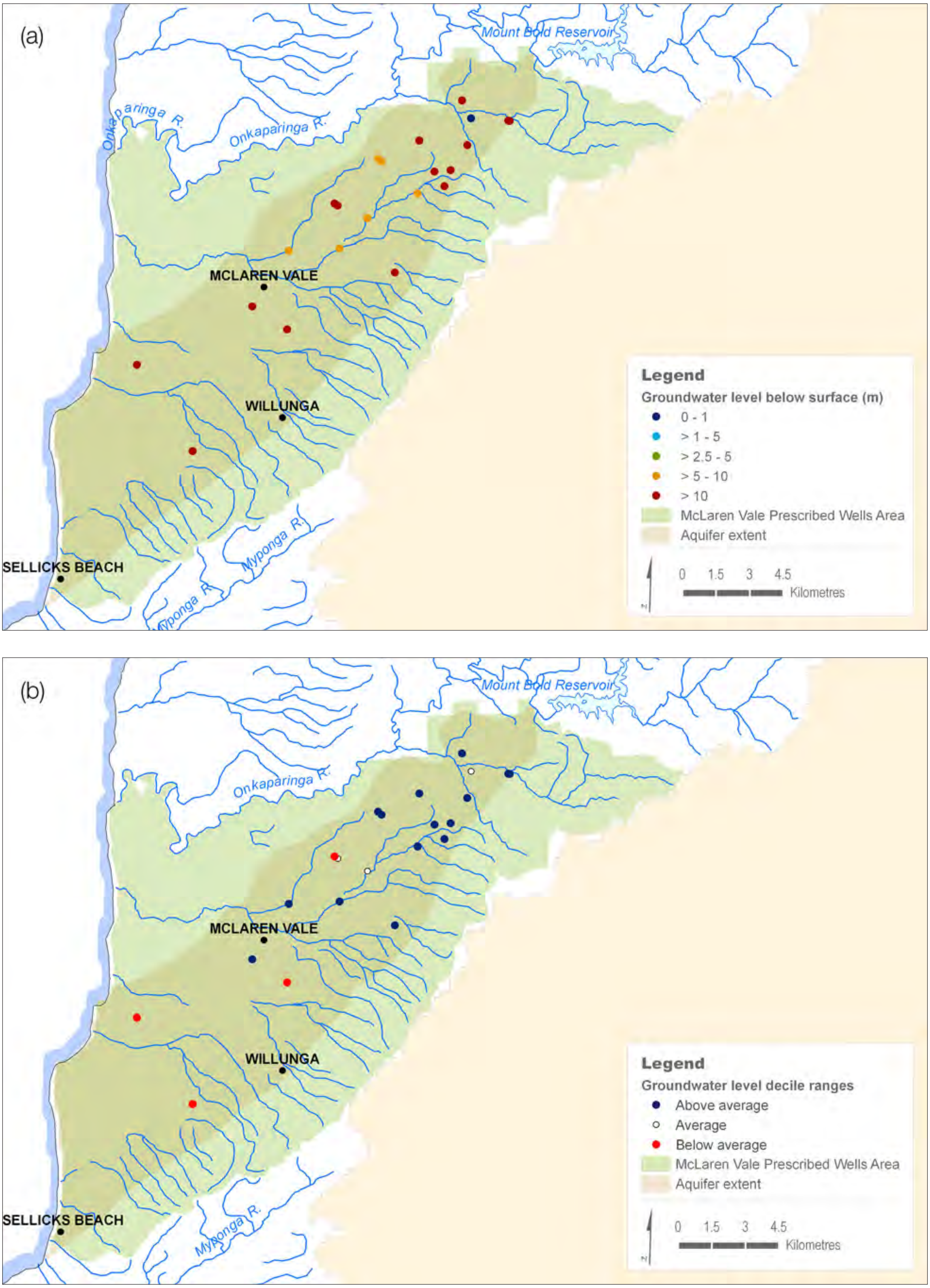



Figure 8.52 (a) Median groundwater depth below surface, and (b) groundwater levels deciles in 2011–12 compared to the 1990–2012 reference period for the Maslin Sands aquifer