# South Western Plateau

# 9. South Western Plateau

## 9.1 Introduction

This chapter examines water resources in the South Western Plateau 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, land use, population and climate.

Spatial and temporal patterns in landscape water flows are presented as well as an examination of the surface and groundwater resources. The data sources and methods used in developing the diagrams and maps are listed in the Technical Supplement.

## 9.2 Key information

Table 9.1 gives an overview of the key components of the data and information in this chapter.

Table 9.1 Key information on landscape water flows and groundwater quality in the South Western Plateau region

| Landscape water flows | | | |
|---|---|---|---|
| | Region average | Difference from 1911–2012 long-term annual mean | Decile ranking with respect to the 1911–2012 record |
| Rainfall | 256 mm | +45% | 9th—above average |
| Evapo-transpiration | 268 mm | +55% | 10th—very much above average |
| Landscape water yield | 6 mm | +100% | 10th—very much above average |
| **Groundwater (in selected aquifers)** | | | |
| | Salinity: | Saline groundwater (≥3000 mg/L) in the south of the region and scattered areas of saline groundwater mainly surrounding (dry) river beds and lakes in the north | |

## 9.3 Description of the region

The South Western Plateau region covers 1,093,000 km$^2$ of mostly sandy or stony desert within Western Australia, South Australia and the Northern Territory. The region borders the South Australian Gulf region to the east, Lake Eyre Basin region to the northeast, Tanami – Timor Sea Coast and North Western Plateau regions to the north, and the Pilbara–Gascoyne and South West Coast regions to the west. The Southern Ocean is the southern boundary of the region.

The region includes the Nullarbor Plain in the south and a major part of the Great Victorian Desert in the north. Vegetation is sparse with trees largely non-existent. The region is predominantly flat with some hills along the edges of the Nullarbor Plain. Subsections 9.3.1– 9.3.4 give more detail on physical characteristics of the region.

The South Western Plateau region has a population of 72,400 people that accounts for just over 0.3% of the nation's total population (Australian Bureau of Statistics [ABS] 2011b).

Major population centres in the region include Kalgoorlie–Boulder, Esperance, Ceduna, Coolgardie, Kambalda West and Streaky Bay (Figure 9.1).

Further discussion of the region's population distribution and urban centres can be found in Section 9.3.6.

Most of the region comprises nature conservation (Figure 9.1), including much of the Nullarbor Plain and the Great Victorian Desert. To the west and east, large areas of pasture are present, with some areas of dryland agriculture on the Eyre Peninsula (southeast) and north of Esperance (southwest).

Except for the western and eastern parts of the region, the vast area of the region is arid. Subsections 9.3.7 and 9.3.8 provide more information on the rainfall patterns and deficits across the region.

A substantial number of predominantly dry lakes are present in the west and east of the region as well as more sporadically in the north. Some small rivers discharge into the Southern Ocean surrounding Esperance in Western Australia and Ceduna in South Australia.

The hydrogeology of the region is dominated by a outcropping fractured basement rock with limited groundwater resources. There are significant groundwater resources in localised sedimentary aquifers.

The Nullarbor Plain | Heidi Kaldahl

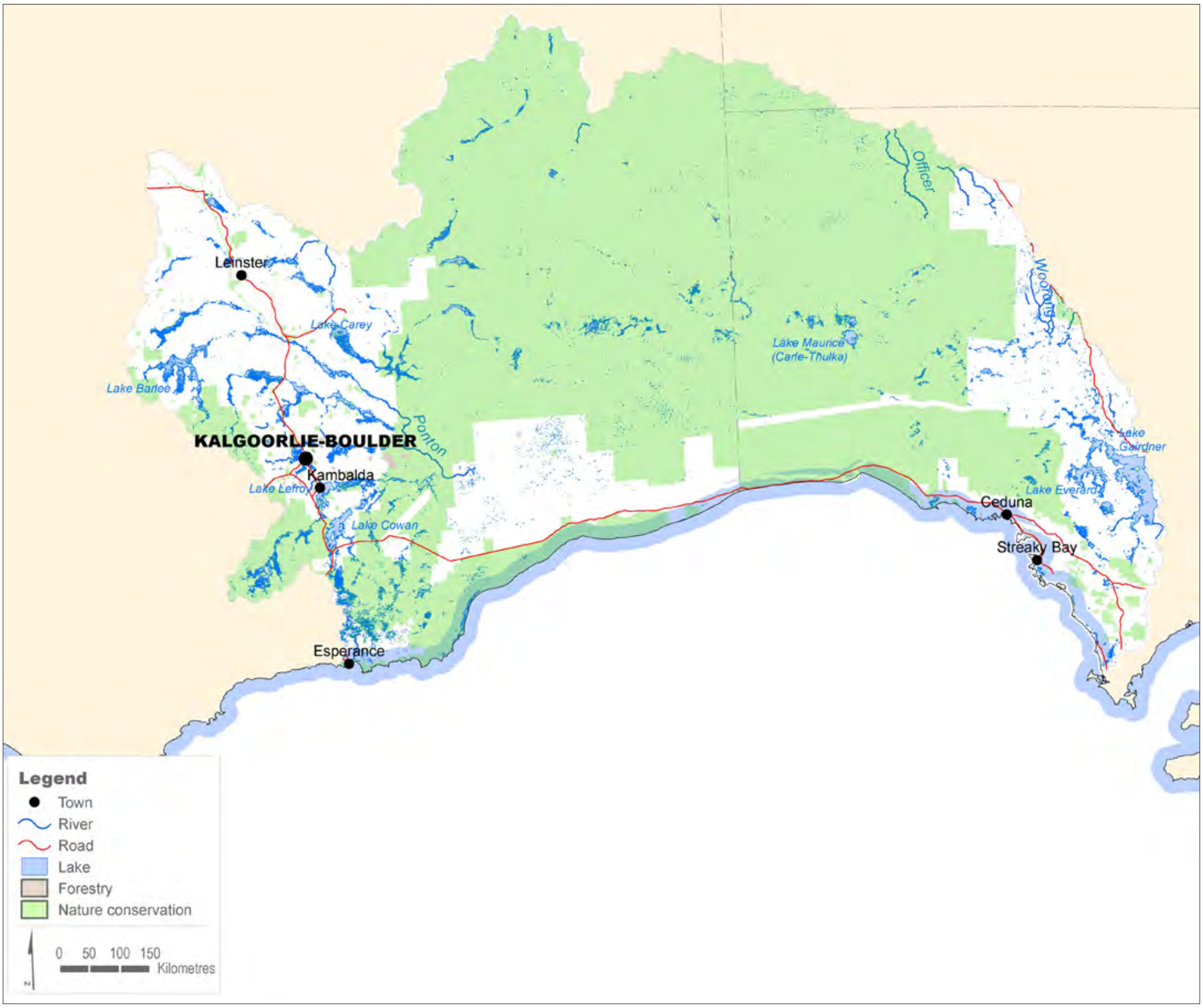



Figure 9.1 Major rivers and urban centres in the South Western Plateau region

### 9.3.1 Physiographic characteristics

The physiographic map in Figure 9.2 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 Western Plateau region has four such dominant physiographic provinces, namely:

- Sandland (41%): west-east longitudinal dunes, broken by low tablelands and ridges in the northwest with ferruginous plains in the north;
- Yilgarn Plateau (24%): flat to undulating plain with salt lakes;
- Nullarbor (21%): karst plain of flat-lying limestone and calcrete; and
- Eyre Peninsula (10%): alluvial plains and salt lakes with some dunes and hills of volcanic and metamorphic rocks in the south.

The remaining three provinces occupy only 4% of the region. These are:

- Central Australian Ranges: dissected sandstone, granitic and volcanic ranges with prominent escarpments; separated by sandplains with dunes of hardpan;
- Central Lowlands: silcrete capped low tablelands; and
- Pilbara: mainly alluvial lowland with hardpan and sand plains.

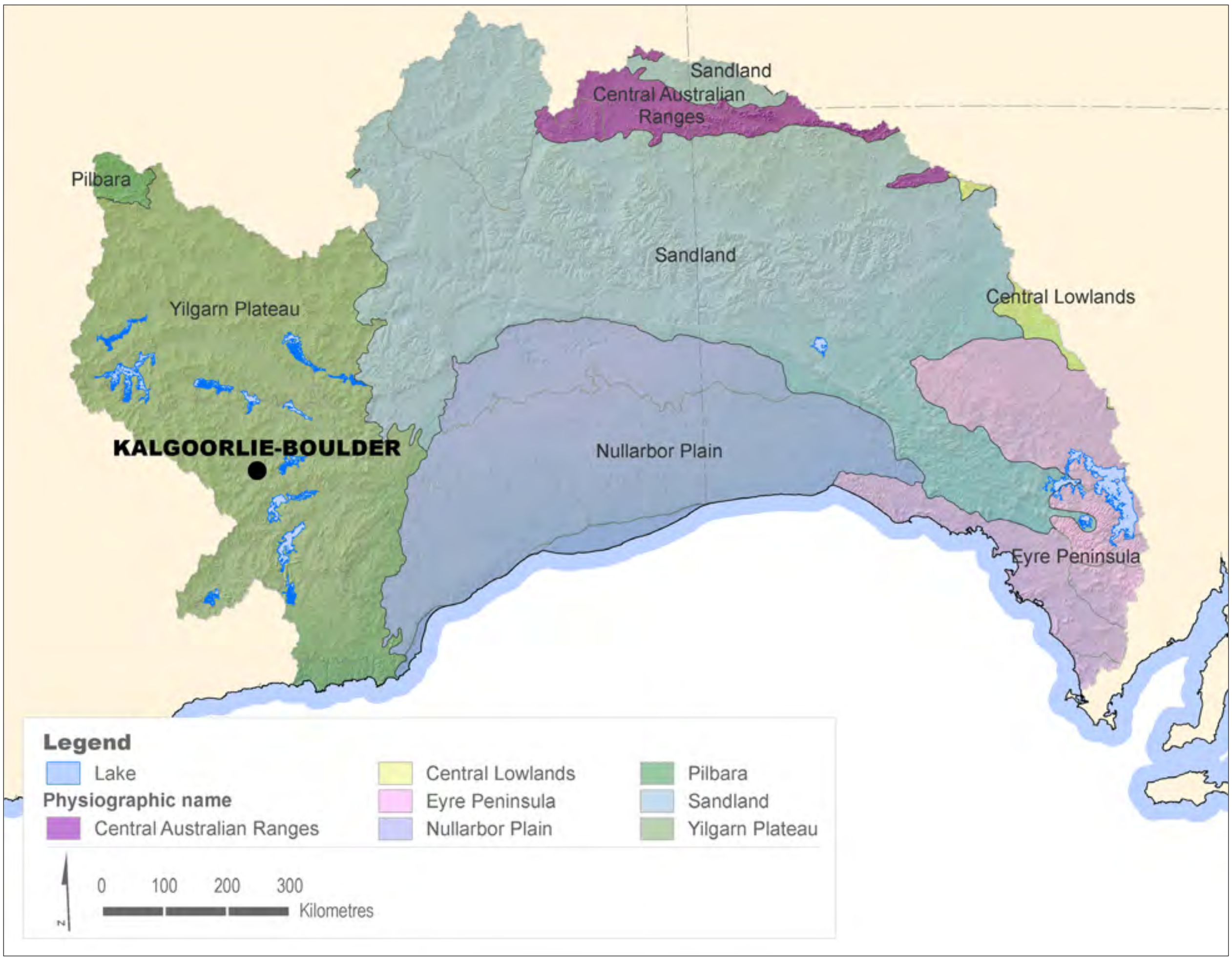



Figure 9.2 Physiographic provinces of the South Western Plateau region

## 9.3.2 Elevation

The South Western Plateau region includes the Nullarbor Plain in the south and a major part of the Great Victorian Desert in the north. As seen in Figure 9.3, the region is predominantly flat with some hills along the edges of the Nullarbor Plain. Information was obtained from the Geoscience Australia website (www.ga.gov.au/topographic-mapping/digital-elevation-data.html).

The north and west of the region is part of the Western Plateau, which extends north and west to the Indian Ocean.

The highest points in the region exceed 1,200 m and are located in the northeastern Musgrave Ranges. The lowest area is the Roe Plains, a long coastal stretch of a low-lying limestone plateau.

The most eastern part of the region has no major hills and altitudes do not exceed 500 m above sea level in the Gawler Ranges. To the west, the area consists of many closed basins in between the ridges, with many dry lakes and salt plains. Altitudes in this area exceed 600 m above sea level.

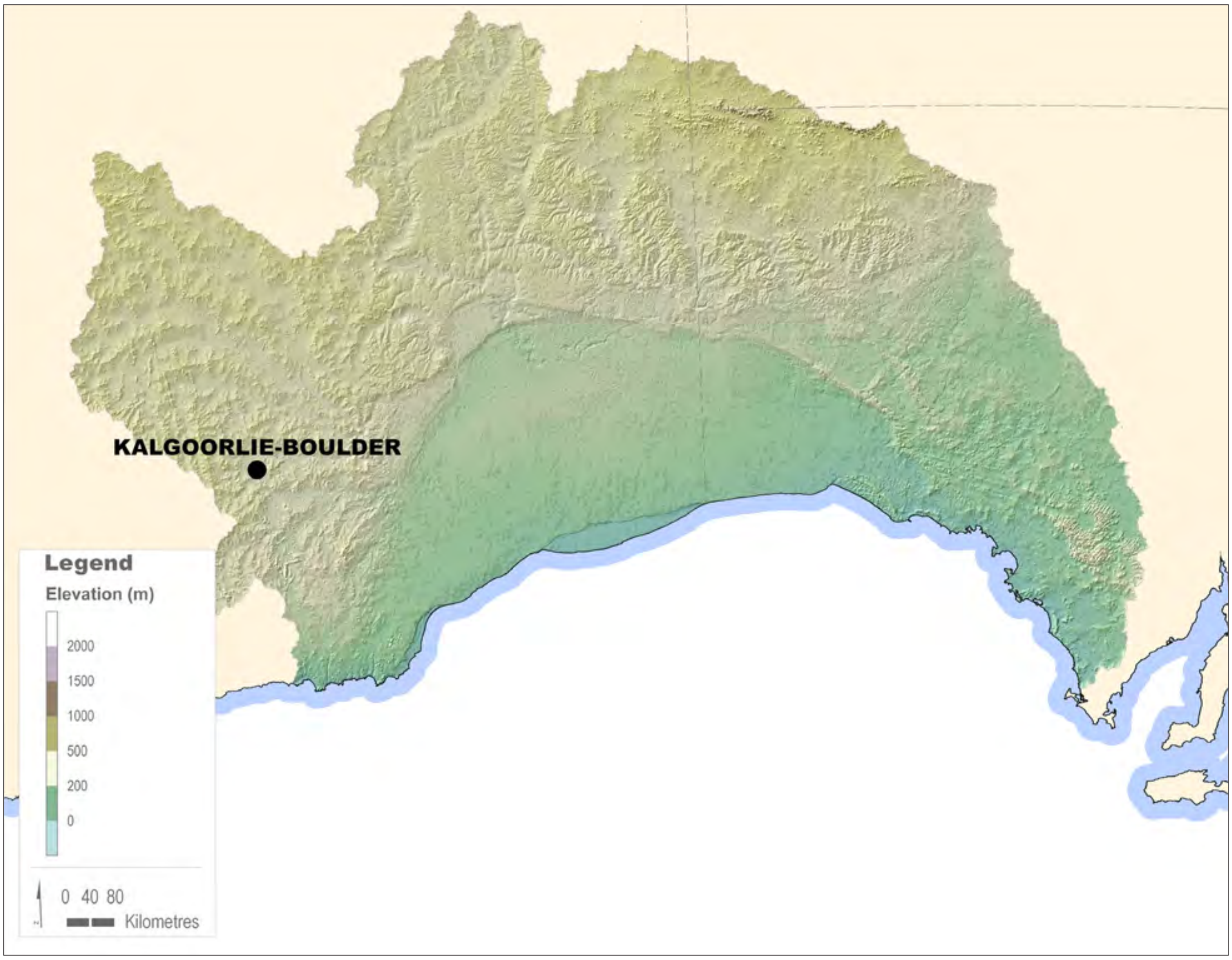



Figure 9.3 Ground surface elevations in the South Western Plateau region

### 9.3.3 Slopes

Areas with steep slopes provide higher run-off generating potential than flat areas. The South Western Plateau region is generally flat, with hardly any steep slopes. Figure 9.4 shows the spatial distribution of surface slopes in the region while Table 9.2 summarises the extent of the slope ranges.

Table 9.2 Proportions of slope classes for the region

| Slope class (%) | 0–0.5 | 0.5–1 | 1–5 | > 5 |
|---|---|---|---|---|
| Proportion of region (%) | 52.4 | 26.8 | 20.0 | 0.8 |

The steep slopes in Figure 9.4 in particular highlight the Musgrave Ranges in the north. The large Nullarbor Plain in the south is very distinctive in its flatness. Water flow is practically non-existent in this area.

The slope map also clearly shows the escarpment of the western plateau in the north and the separation between the Nullarbor Plain and the Roe Plains in the south. The slopes were derived from the elevation information used in the previous section.

The ridges to the west are particularly distinctive as well, with many flat areas in between depicting the large dry lakes and salt plains.


Figure 9.4 Surface slopes in the South Western Plateau region

## 9.3.4 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 contributing to groundwater recharge. The nature of these hydrological pathways and the suitability of the soilds for agricultural purposes are influenced by the soil types and their characteristics. Soil type information was obtained from the Australian Soil Resource Information System website (www.asris.csiro.au).

About 97% of the South Western Plateau region is covered by four soil types, namely tenosols, calcarosols, rudosols and kandosols (Figure 9.5 and Figure 9.6). They are mostly present in areas used for grazing or nature conservation. Among these soils tenosols and calcarosols each cover more than 30% of the region.

Tenosols, rudosols and kandosols are soils with weak and minimal development, either throughout the profile (tenosols, rudosols) or in the upper soil profile (kandosols). They show no or little change in texture and colour and are often shallow in depth. These soils are low in chemical fertility and in water-holding capacity and thus their agricultural potential is low.

Tenosols are dominant in the north of the region and here they are found with kandosols. Tenosols are also scattered in the southeast of the region. In the east of the region, rudosols are more common Calcarosols are characterised by a high of calcium carbonate content which occurs as soft or hard white fragments or as solid layers. These soils are found along the coastline and in the eastern part of the region. The soils are often shallow and have a low water-holding capacity. They have low to moderate agricultural potential, and high salinity levels, alkalinity and boron toxicity may often cause problems.

The other soil types that have minimal representation in the South Western Plateau region include sodosols and hydrosols (0.6–3% of the total area).

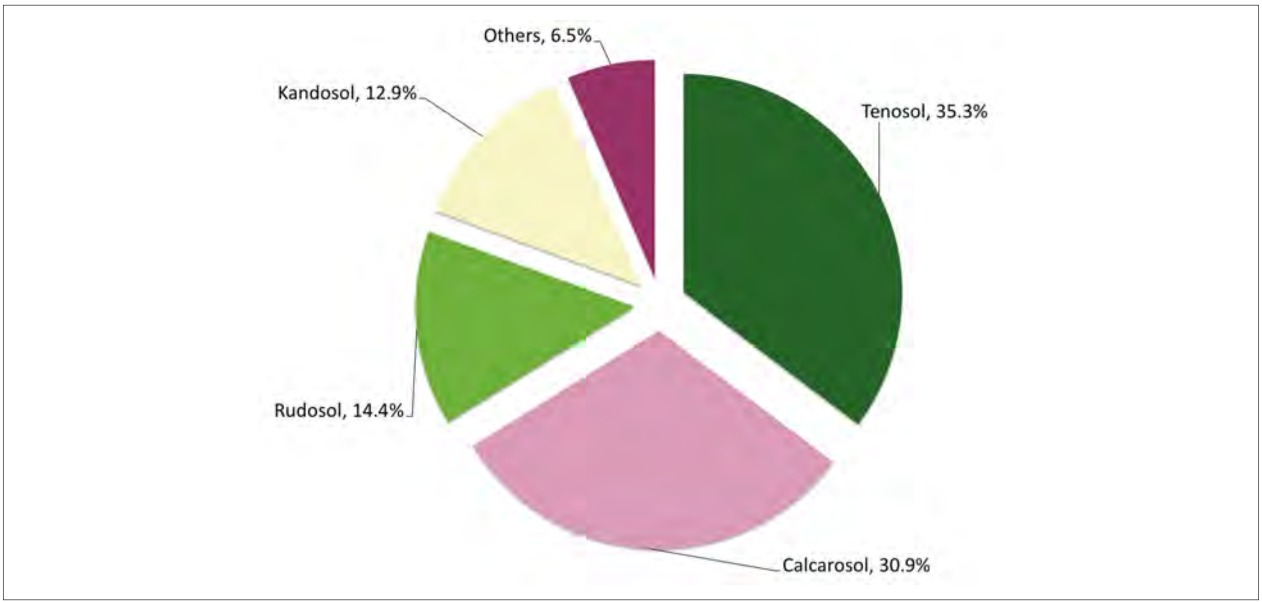



Figure 9.5 Soil types in the South Western Plateau region

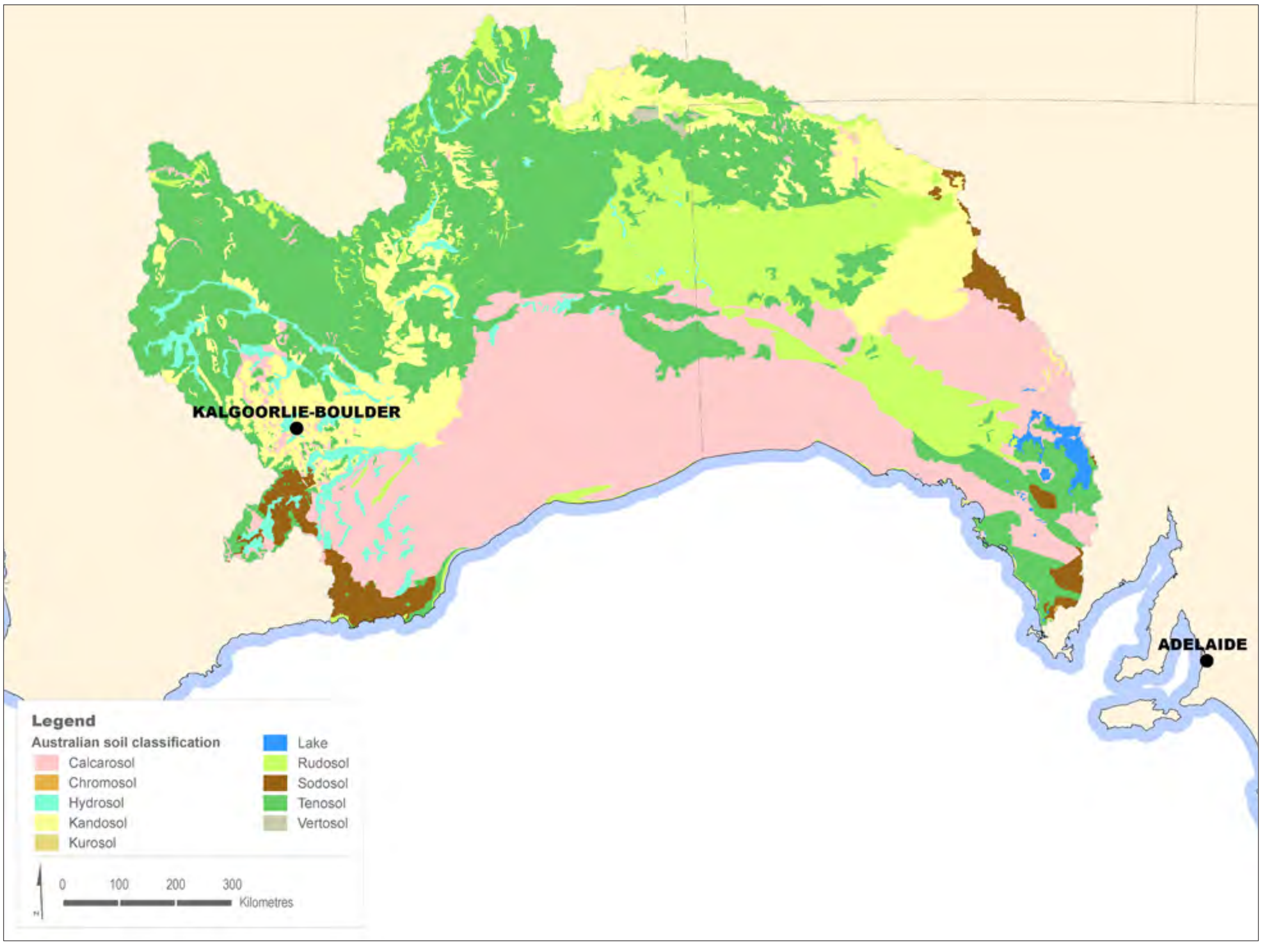



Figure 9.6 Soil type distribution in the South Western Plateau region

## 9.3.5 Land use

As presented in Figure 9.7 and Figure 9.8, most of the region comprises nature conservation, including much of the Nullarbor Plain and the Great Victorian Desert (data from data.daff.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml). To the west and east, large areas of pasture are present with some areas of dryland agriculture on the Eyre Peninsula (southeast) and north of Esperance (southwest).

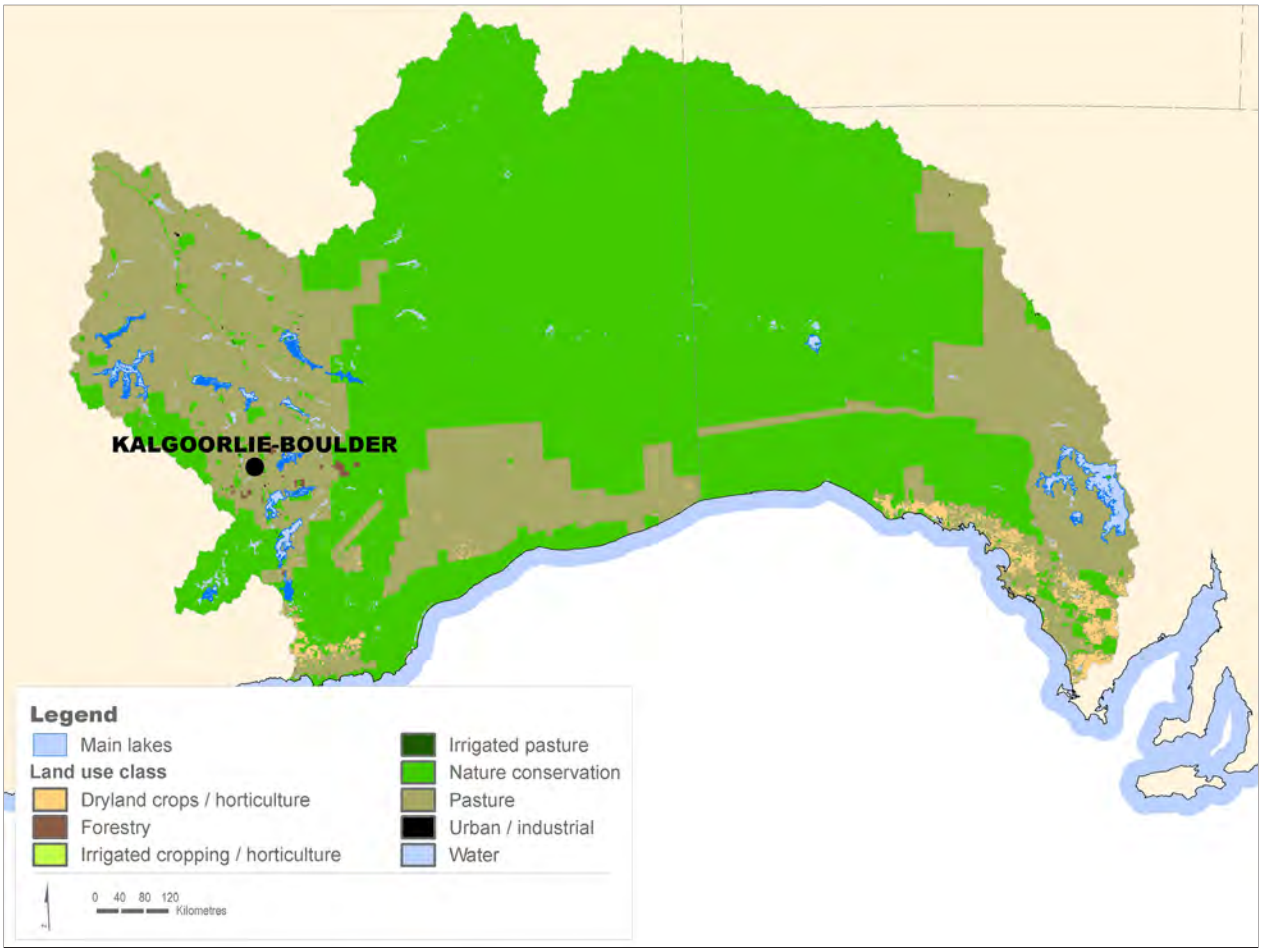



Figure 9.7 Land use distribution in the South Western Plateau region

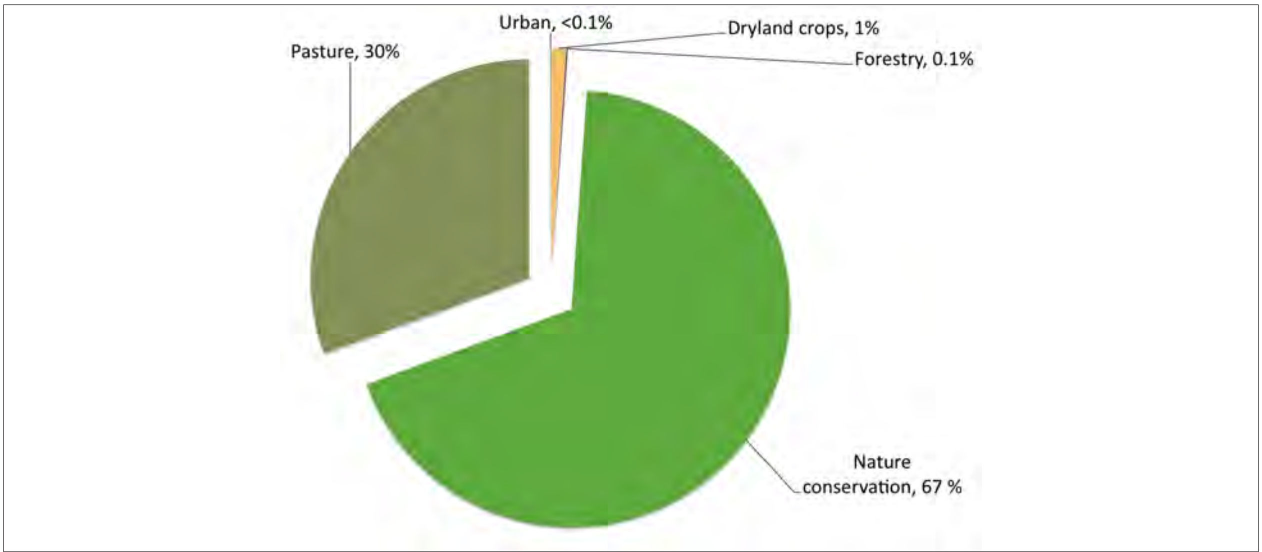



Figure 9.8 Land use in the South Western Plateau region

### 9.3.6 Population distribution

Figure 9.9 illustrates the sparse nature of the population in the region (ABS 2011b).

The majority of the population is located near the eastern and western extremities of the region. The region is home to a number of remote Indigenous communities. Mining is the primary occupation for the majority of the region's sparsely distributed but permanent population centres. The mining city of Kalgoorlie–Boulder is the largest and most densely populated centre within the region and is situated in the central west, within the Western Australian State boundary. In addition to Kalgoorlie, the coastal centre of Esperance is located in the southwest of the region.

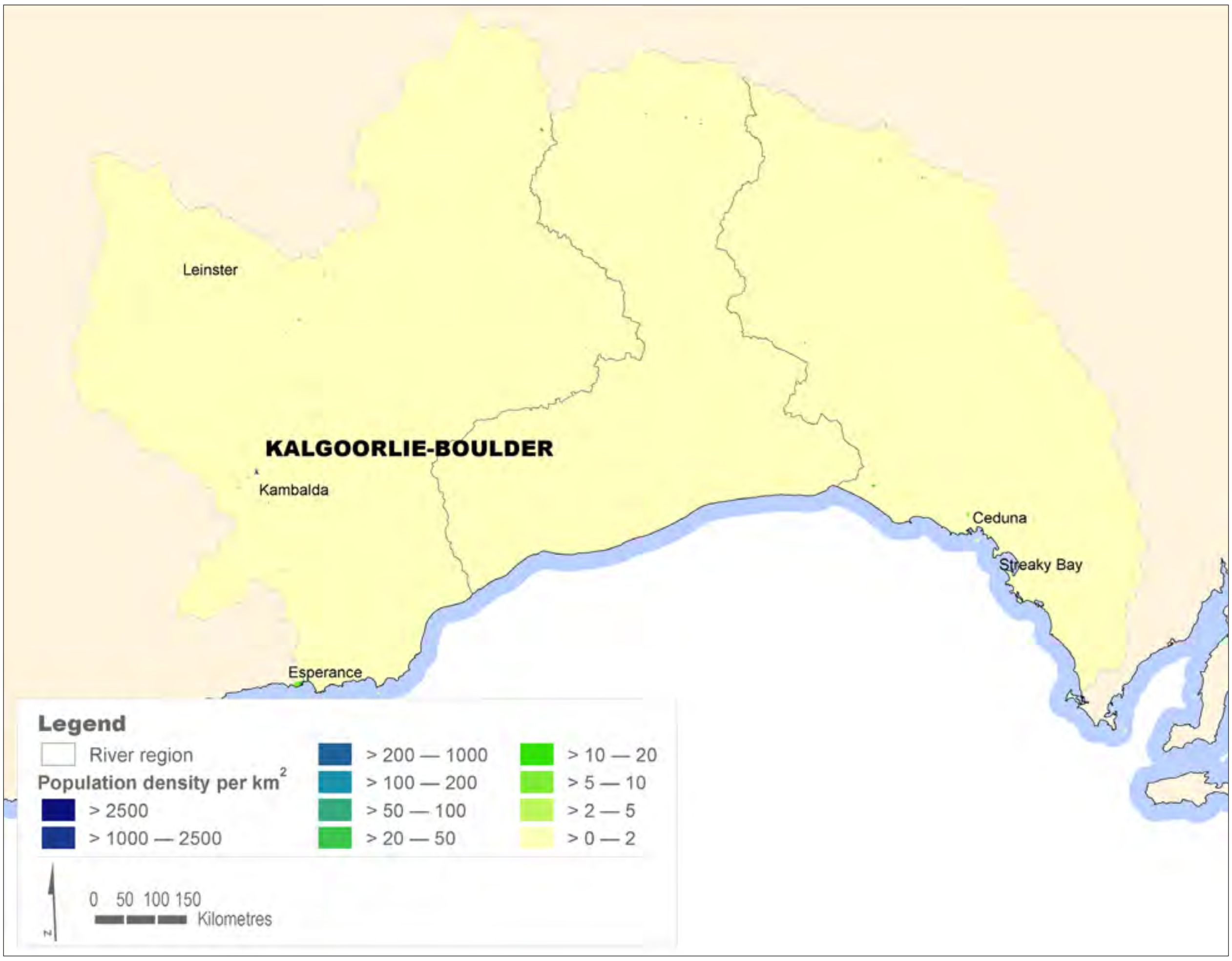



Figure 9.9 Population density and distribution in the South Western Plateau region

### 9.3.7 Rainfall zones

The South Western Plateau region is the driest region in Australia. Except for the southwest and southeast of the region, which are semi-arid, the vast area in the centre is arid. With the exception of the far western coastline, median rainfall does not exceed 500 mm per year (Figure 9.10).

A large portion of the region has the lowest average annual rainfall of the continent, not exceeding 200 mm.

The winter (dominant) rainfall areas in the west and east have annual average rainfall totals of about 300 mm. In the far southeast, some consistency in winter rainfall is present, although annual average rainfall does not exceed 500 mm.

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 9.10 Rainfall zones in the South Western Plateau region

### 9.3.8 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 Western Plateau region is highly prone to water shortages in relation to this indicator.

High deficits can be expected in large parts of the inland areas where desert vegetation prevails (Figure 9.11). 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

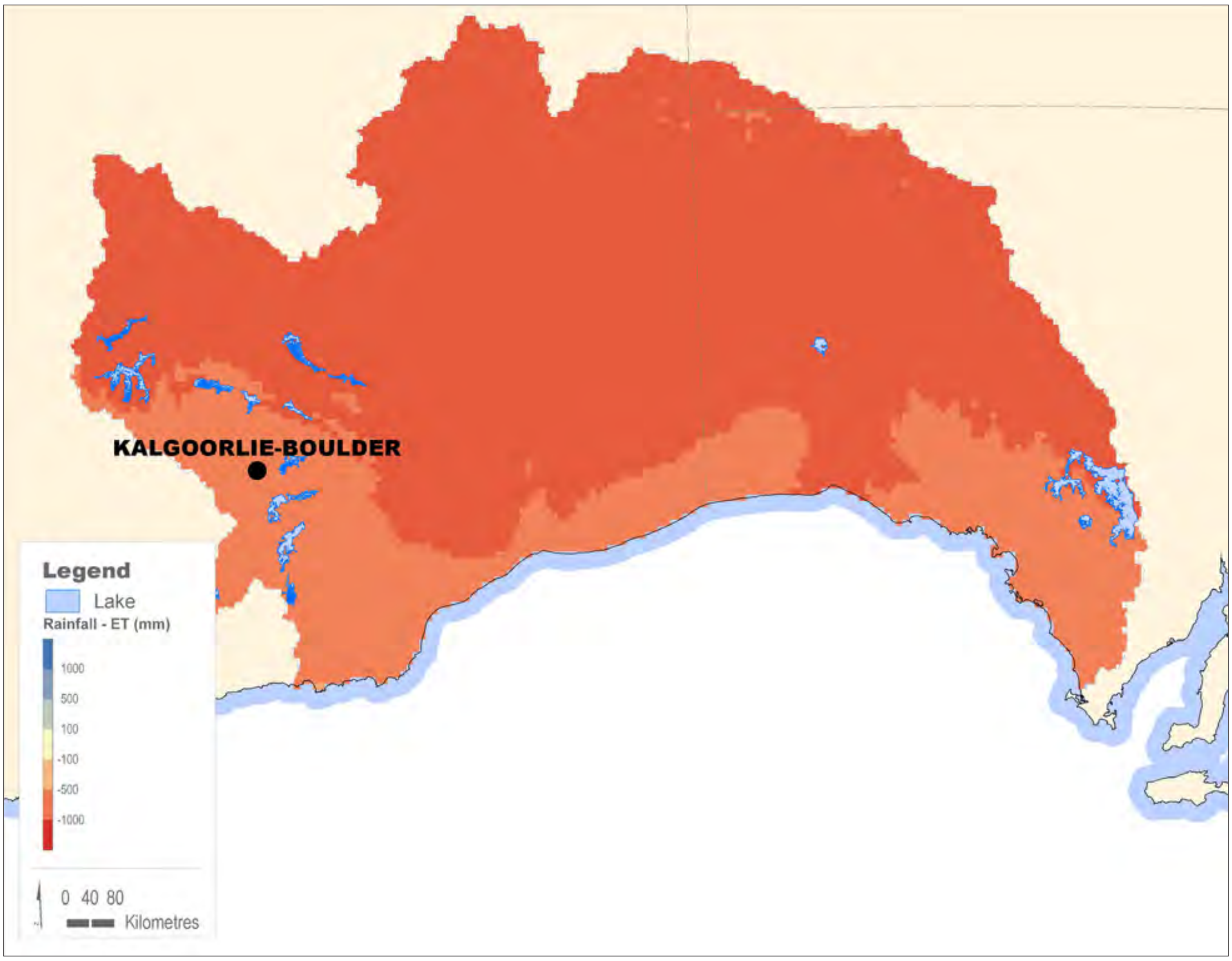



Figure 9.11 Rainfall deficit distribution in the South Western Plateau region

## 9.4 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 Western Plateau 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 Introduction and addressed in more detail in the Technical Supplement.

Figure 9.12 show that the region has a highly variable historic rainfall pattern. No clear seasonality in the rainfall can be identified in the boxes of Figure 9.12. This also counts for the historic annual totals of evapotranspiration and landscape water yield. The historic pattern of evapotranspiration closely follows that of rainfall. Landscape water yield is generally close to zero for each month of the year.

It should be noted that the area has low rain gauge density, particularly in the north, and data uncertainty for the spatially interpolated rainfall data is high. Nonetheless, Figure 9.12 shows that the 2011–12 year was a relatively wet year, especially between October 2011 and January 2012. Above average sea surface temperatures were evident in the Indian Ocean during spring 2011, which generated a large number of thunderstorms over the whole of Western Australia.

Evapotranspiration closely followed the temporal pattern of rainfall. A month's delay is noticeable in the October and November evapotranspiration in relation to rainfall, as evapotranspiration is limited to a maximum potential amount per day, based on available energy levels. Since most of the October rainfall was stored in the soil, it was directly available for evapotranspiration in November.

Throughout most of the year, landscape water yield for 2011–12 was higher than the historic monthly averages. Most of this landscape water yield occurred locally, mainly in the western part of the region.

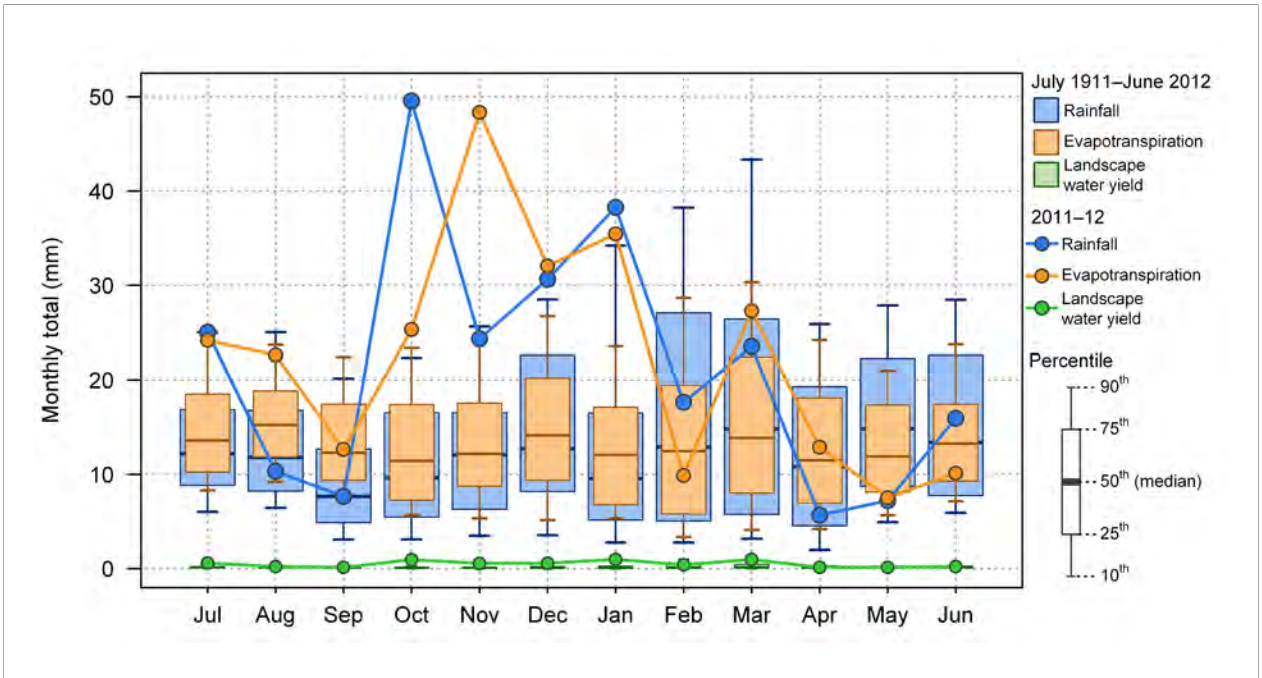



Figure 9.12 Landscape water flows in 2011–12 compared with the long-term record (July 1911–June 2012) for the South Western Plateau region

### 9.4.1 Rainfall

Rainfall for the South Western Plateau region for 2011–12 is estimated to be 256 mm. This is 45% above the region's long-term average (July 1911–June 2012) of 176 mm. Figure 9.13a shows that the highest rainfall occurred largely along the western borders, with annual totals exceeding 400 mm in many areas for 2011–12.

The high data uncertainty in the map indicates those areas where rain gauge density is too low to accurately capture localised rainfall, particularly in the form of thunderstorms.

Rainfall deciles for 2011–12 indicate average to above average rainfall for the entire region over the course of the year (Figure 9.13b). The pasture fields in the northwest of the region locally had very much above average rainfall.

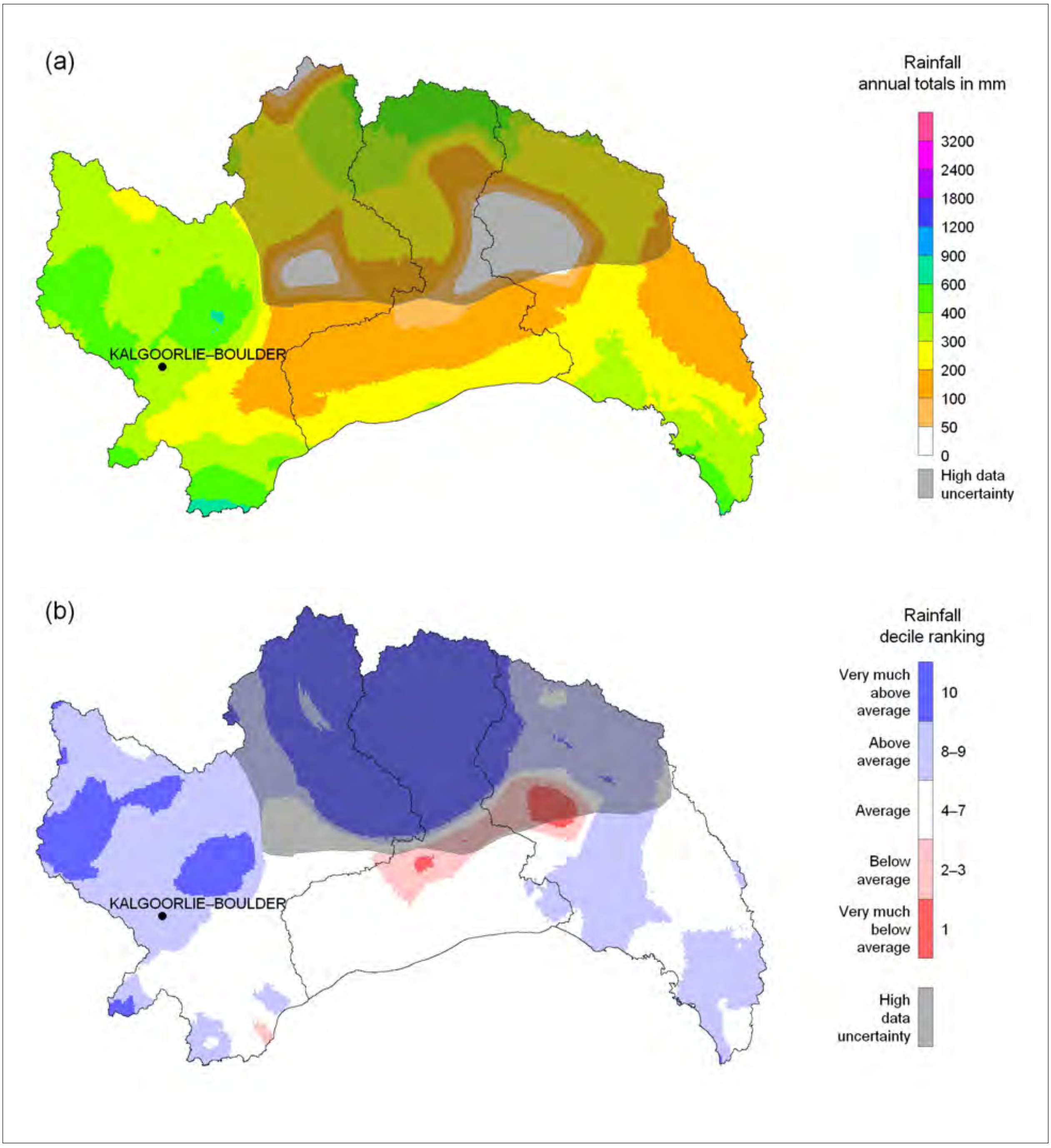
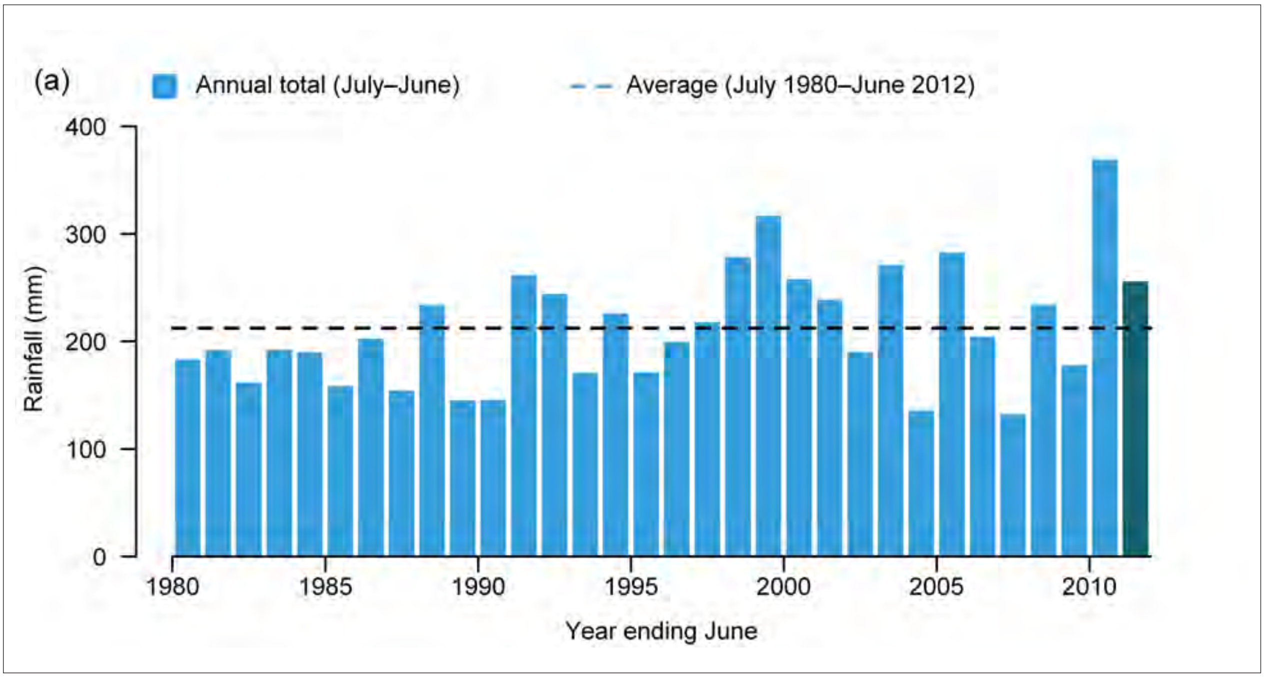



Figure 9.13 Spatial distribution of (a) annual rainfall in 2011–12 and (b) their decile rankings over the 1911–2012 period for the South Western Plateau region

## Rainfall variability in the recent past

Figure 9.14a shows annual rainfall for the region from July 1980 onwards. Over this 32-year period the annual average was 212 mm, varying from 132 mm (2007–08) to 369 mm (2010–11). Temporal variability and seasonal patterns since 1980 are presented in Figure 9.14b.

The graphs indicate a substantial increase in rainfall from 1997 onwards, especially for the summer period. Where rainfall was equally distributed between the summer and winter period in the first half of the 32-year period, summer rainfall suddenly increased to higher totals in the second half of the period.



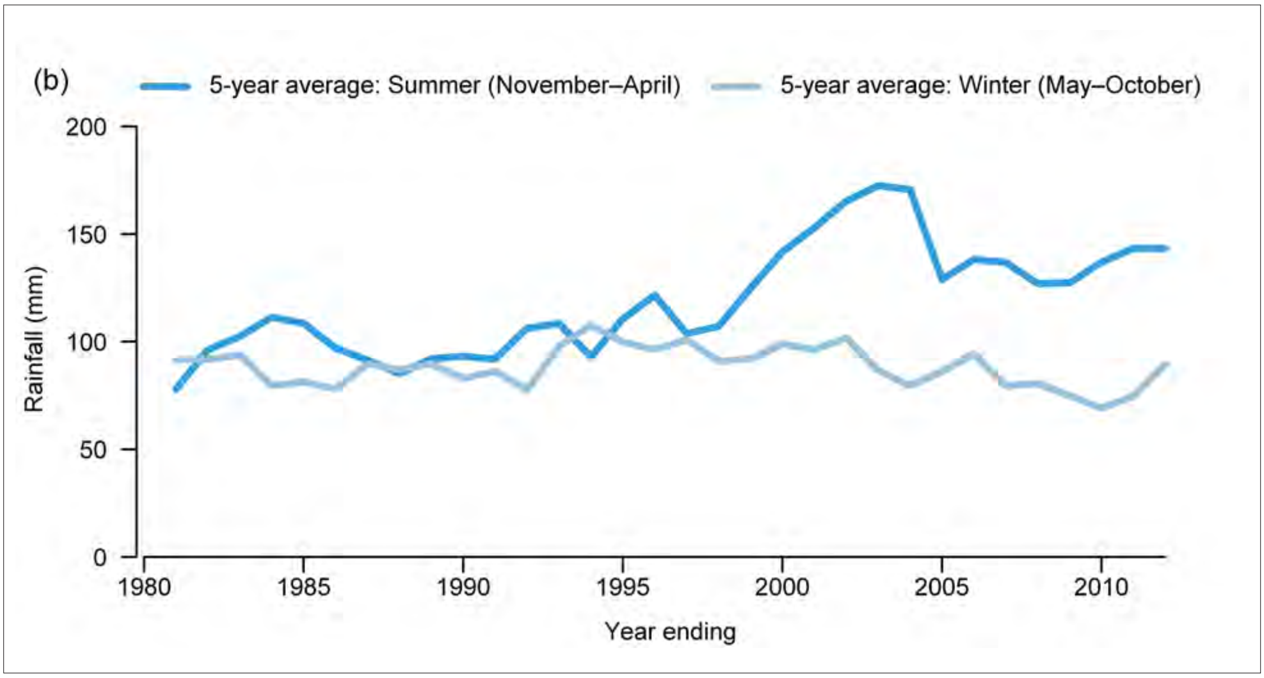




Figure 9.14 Time-series of (a) annual rainfall, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the South Western Plateau region

### Recent trends in rainfall

Figure 9.15a 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 9.15b.

Figure 9.15a shows that since 1980 an increase in rainfall has occurred in most of the region, particularly in the data sparse north. Some areas with a significant rising trend are present on the Nullarbor in the centre of the region. The more cultivated southwest and southeast of the region had no change in annual rainfall since 1980.

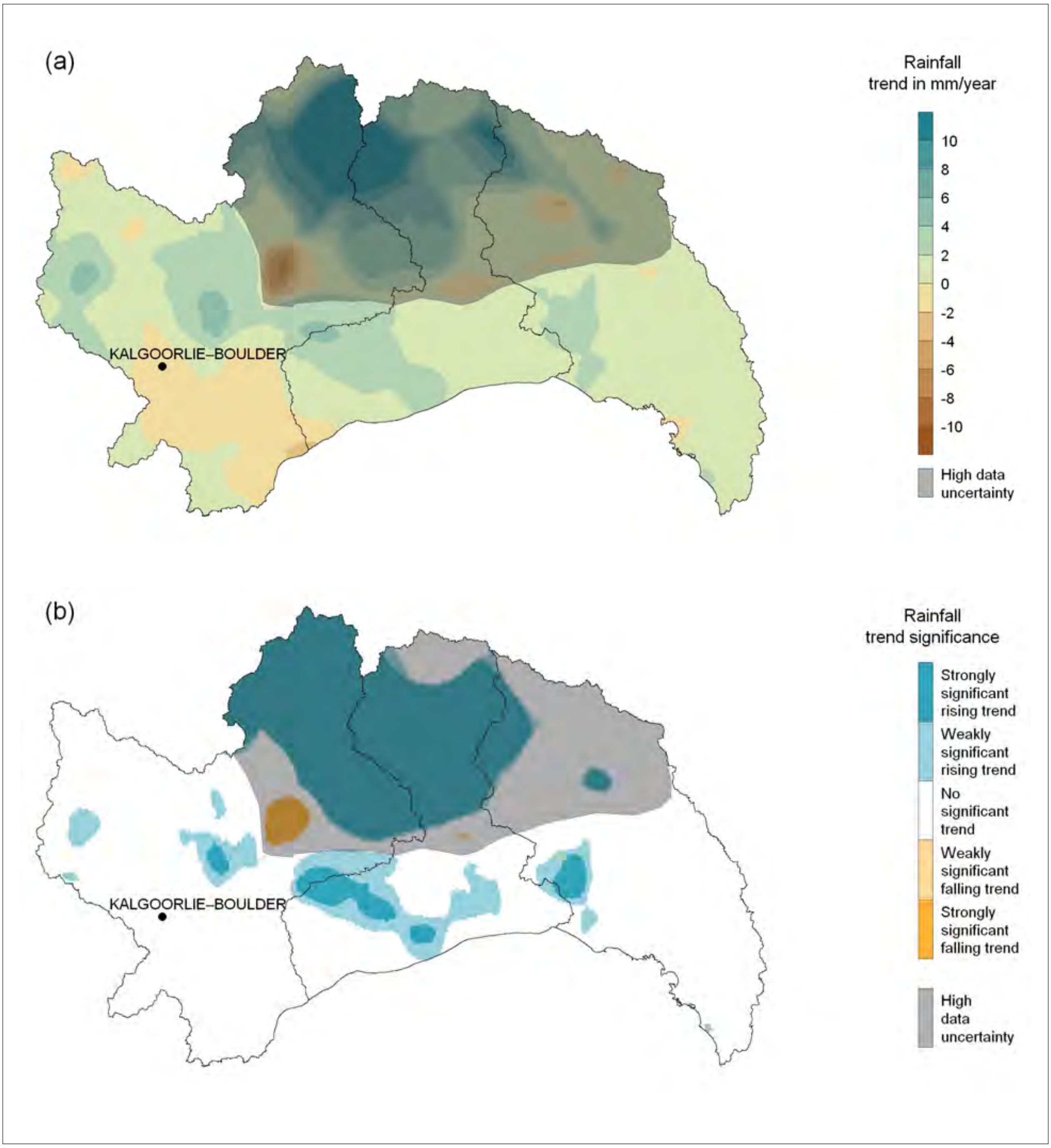



Figure 9.15 Spatial distribution of (a) trends in annual rainfall from 1980–2012 and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the South Western Plateau region

## 9.4.2 Evapotranspiration

Modelled annual evapotranspiration for the South Western Plateau region for 2011–12 is estimated to be 268 mm. This is 55% above the region's long-term (July 1911–June 2012) average of 173 mm. The spatial distribution of annual evapotranspiration in 2011–12 (Figure 9.16a) is closely related to that of rainfall (Figure 9.13a).

Evapotranspiration deciles for 2011–12 indicate very much above average totals across most of the north of the region (Figure 9.16b). In the south, where the water supply through rainfall was largely average, evapotranspiration was also not able to exceed average levels.

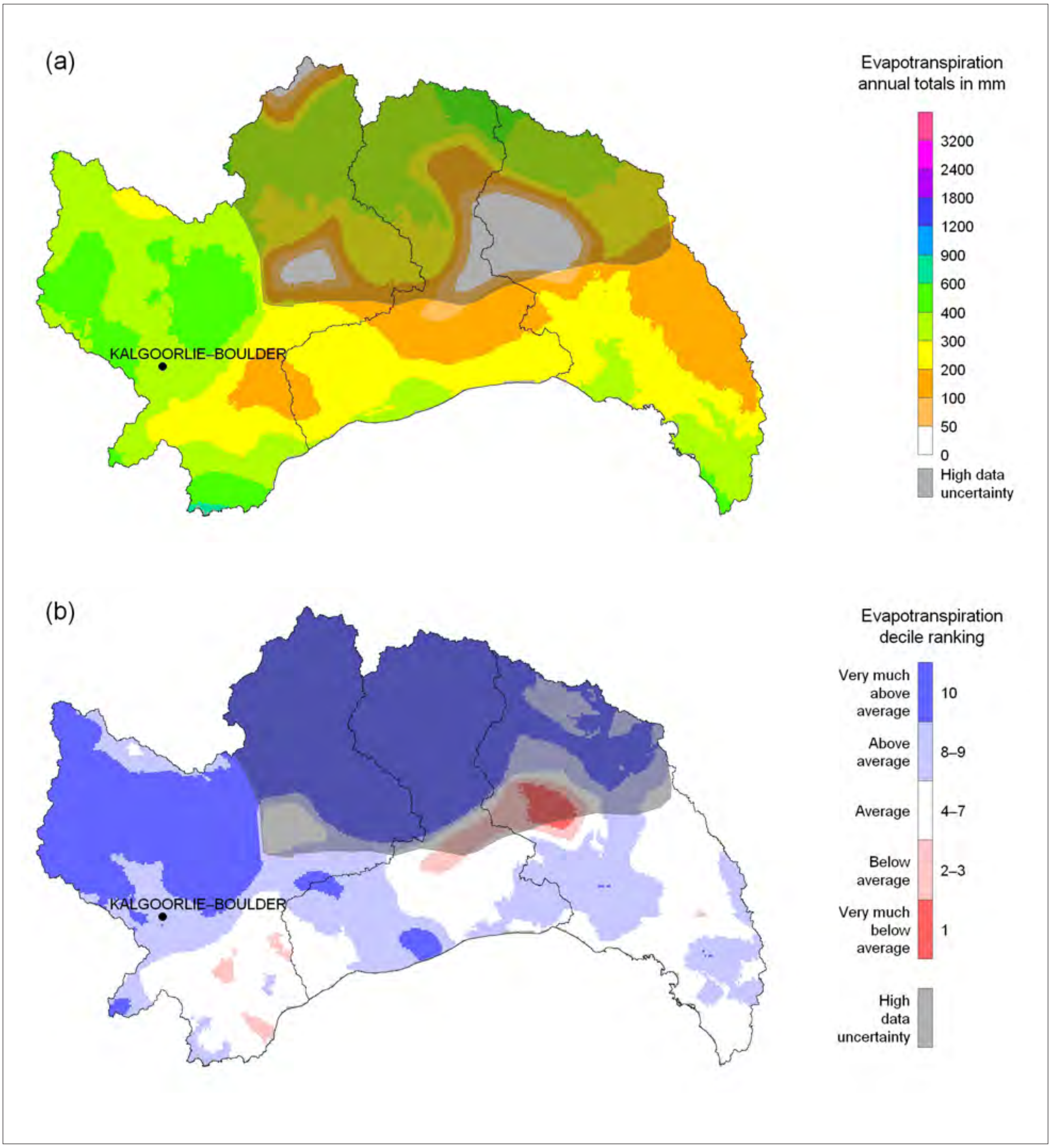
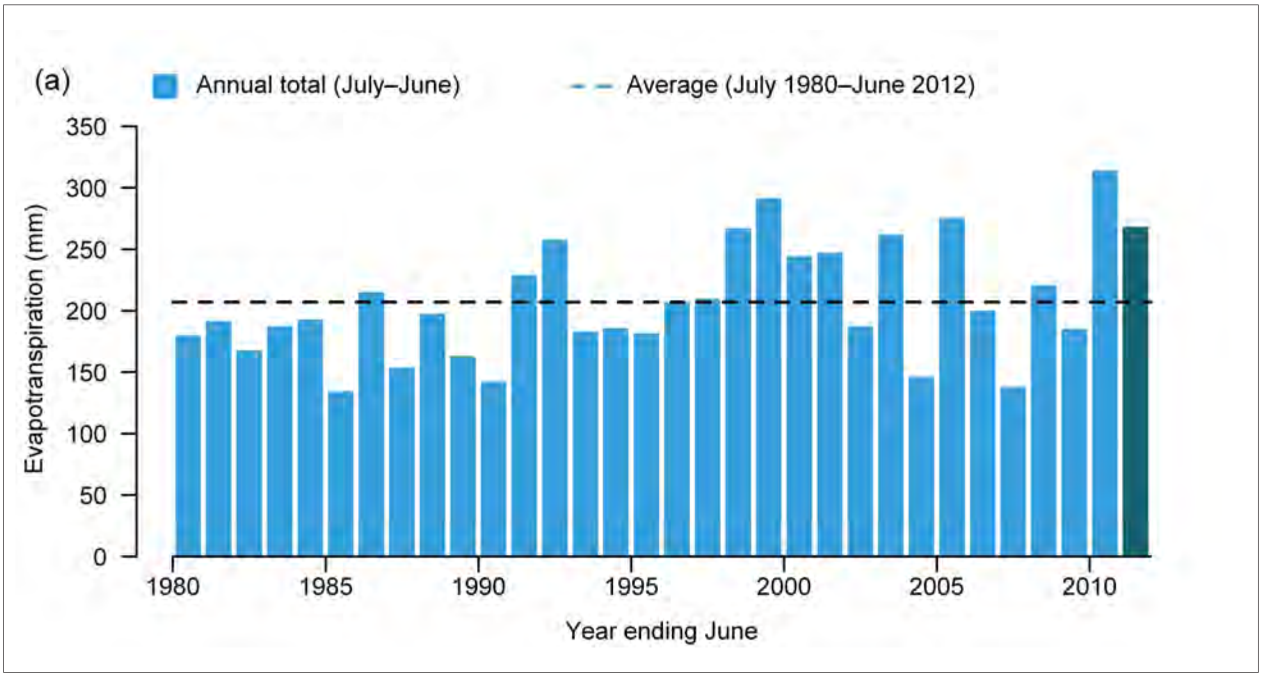



Figure 9.16 Spatial distribution of (a) modelled annual evapotranspiration in 2011–12, and (b) their decile rankings over the 1911–2012 period for the South Western Plateau region

### Evapotranspiration variability in the recent past

Figure 9.17a shows annual evapotranspiration for the region from July 1980 onwards. Over this 32-year period the annual evapotranspiration average was 207 mm, varying from 134 mm (1985–86) to 314 mm (2010–11). Temporal variability and seasonal patterns since 1980 are presented in Figure 9.17b.

Similar to the temporal pattern of rainfall, evapotranspiration shows an increase in annual totals after 1997, mainly occurring in the summer period. Water availability, provided by rainfall, is the only limitation to evapotranspiration in this arid region.



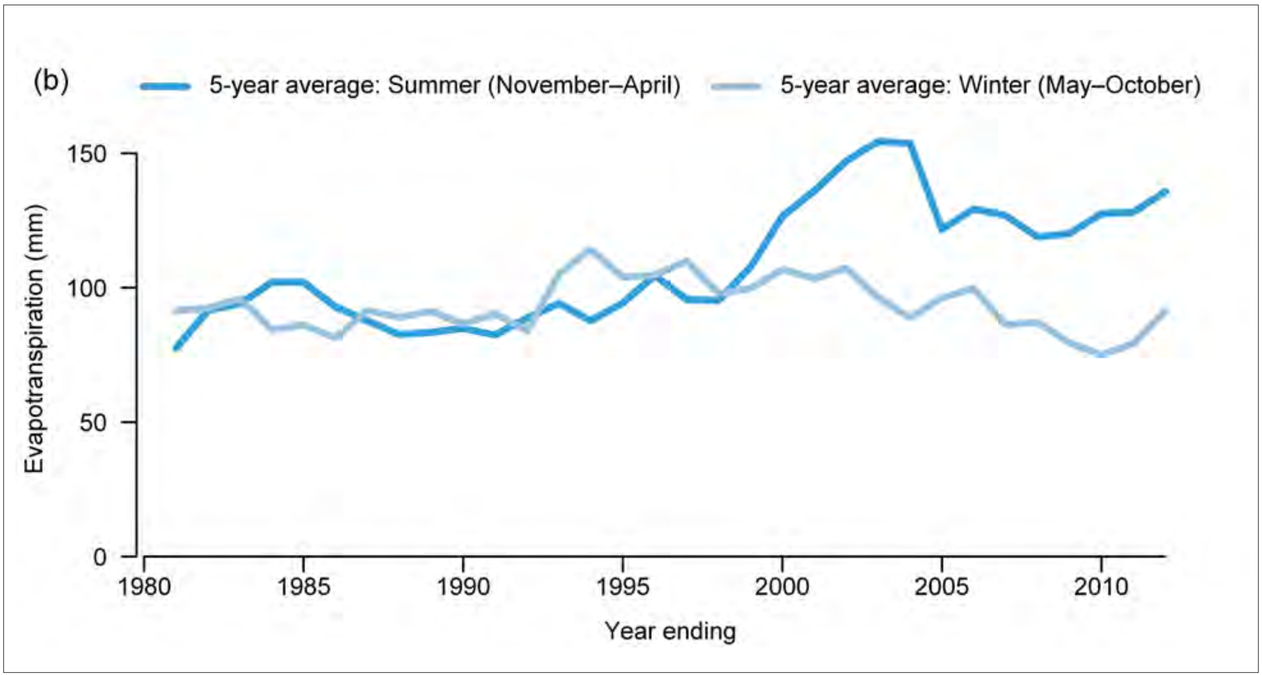




Figure 9.17 Time-series of (a) annual evapotranspiration and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the South Western Plateau region

## Recent trends in evapotranspiration

Figure 9.18a 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. The statistical significance of the trends is provided in Figure 9.18b.

Figure 9.18a shows that, since 1980, trends are mostly positive in the central northern part of the region. In the south, the trends are mostly neutral.

As shown in Figure 9.18b, some statistically significant rising trends in annual evapotranspiration are present in the data sparse north and in large areas in the centre of the region. As evapotranspiration is driven by the availability of moisture, these spatial patterns are again linked to the rainfall trends of Figure 9.15.

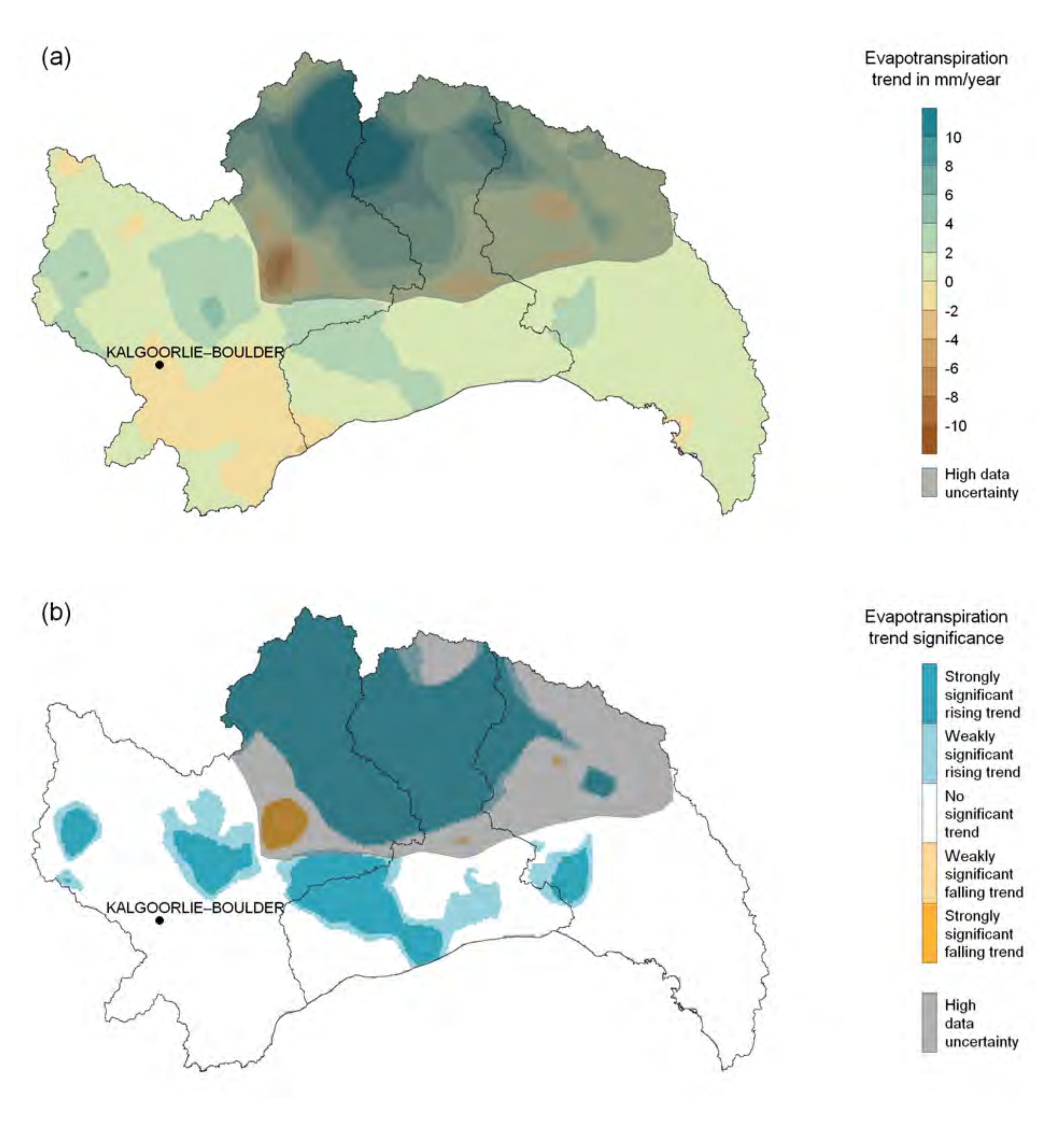



Figure 9.18 Spatial distribution of (a) trends in annual evapotranspiration from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the South Western Plateau region

### 9.4.3 Landscape water yield

Modelled landscape water yield for the South Western Plateau region for 2011–12 is estimated to be 6 mm. This is 100% above the region's long-term (July 1911–June 2012) average of 3 mm. Figure 9.19a shows the spatial distribution of landscape water yield for 2011–12, which is similar to the annual rainfall distribution (Figure 9.13a; note the difference in the scale of the two figures).

The decile ranking map for 2011–12 (Figure 9.19b) shows above average to very much above average landscape water yields in most parts of the region. Some below average landscape water yield occurred in the southwest of the region. Throughout the area the model estimates landscape water yields which vary marginally. Only minor differences from the mean could cause areas to appear as above or below average.

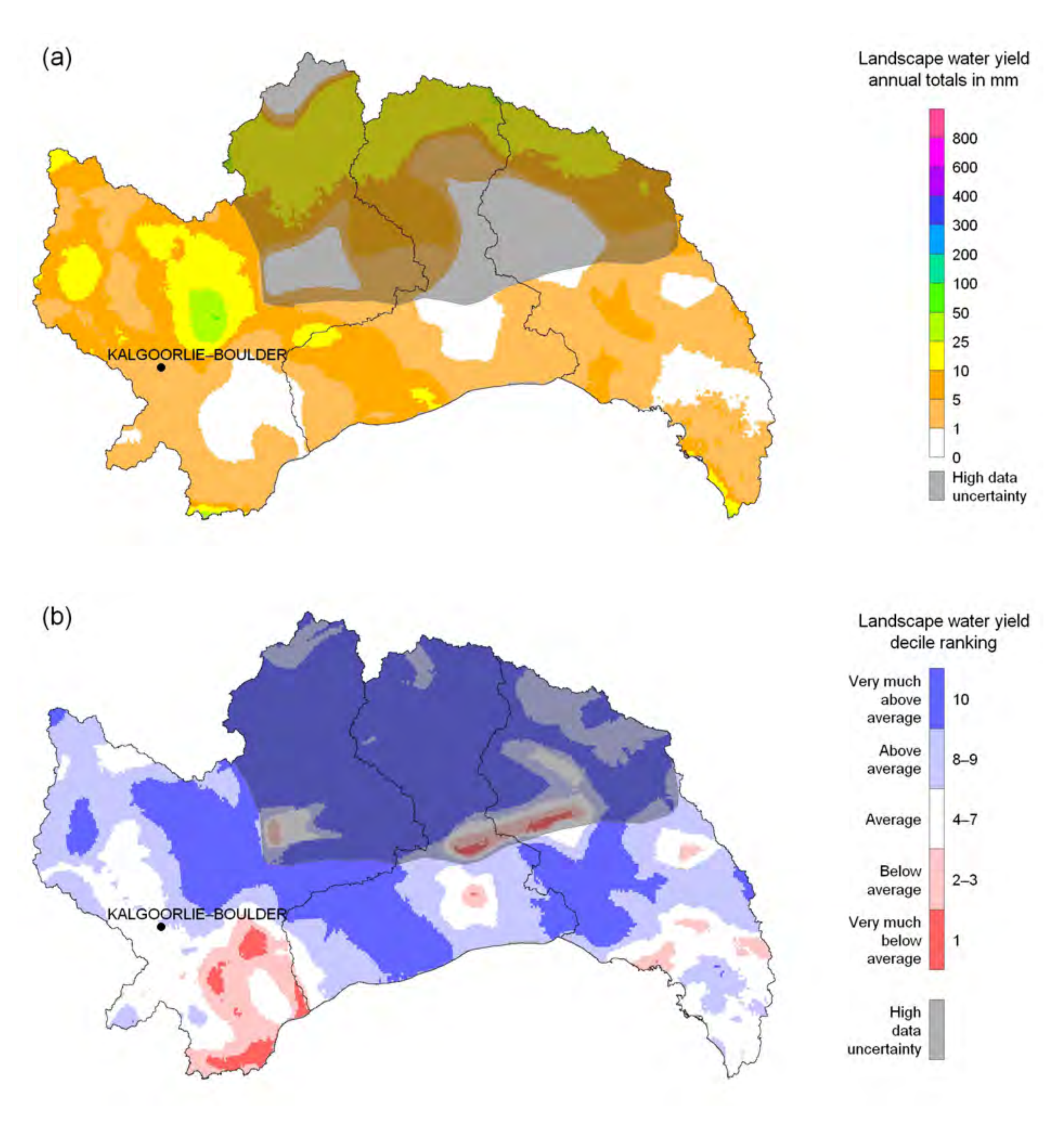


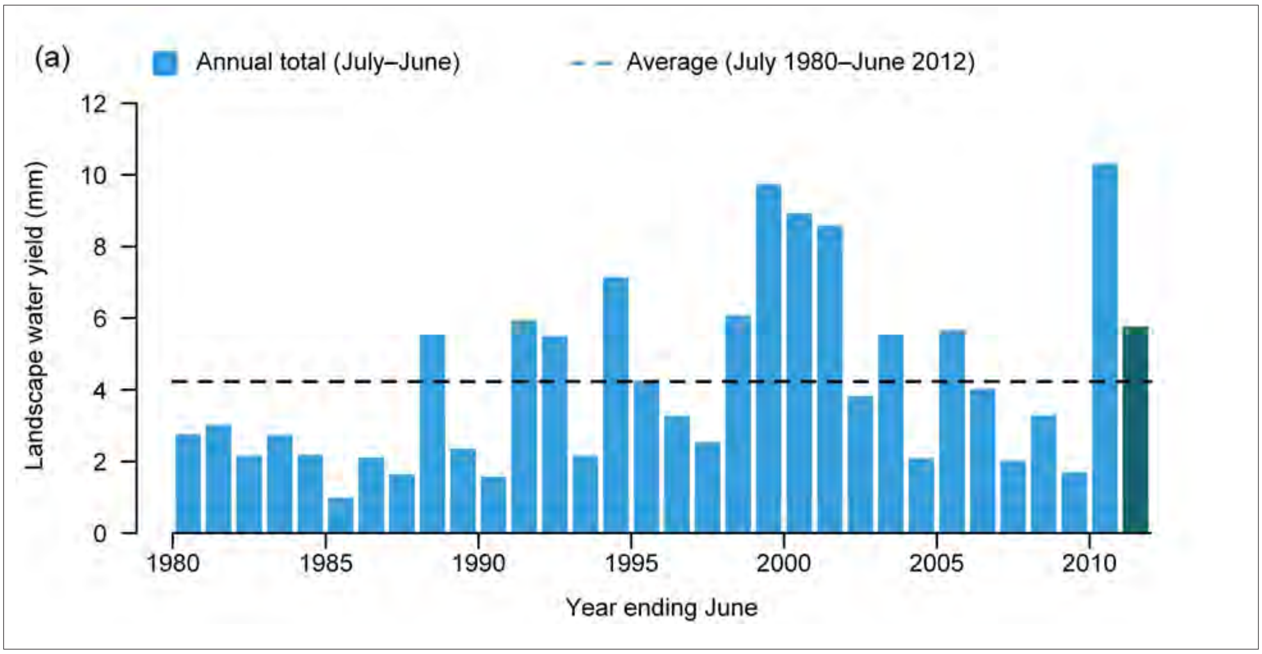

Figure 9.19 Spatial distribution of (a) modelled annual landscape water yield in 2011–12 and (b) their decile rankings over the 1911–2012 period for the South Western Plateau region

## Landscape water yield variability in the recent past

Figure 9.20a shows annual landscape water yield for the South Western Plateau region from July 1980 onwards. Over this 32-year period, annual landscape water yield was 4 mm, varying from 1 mm (1985–86) to 10 mm (2010–11). Temporal variability and seasonal patterns since 1980 are presented in Figure 9.20b.

The high variability in annual landscape water yield is normal for arid areas. These areas experience only a small number of rainfall events, of which only the high intensity events have the potential to generate landscape water yield.

Landscape water yield is consistently higher during the summer period compared to the winter period, with, however, an increase in the gap between the two seasons since 1997. This again corresponds with the temporal patterns in rainfall of Figure 9.14b.



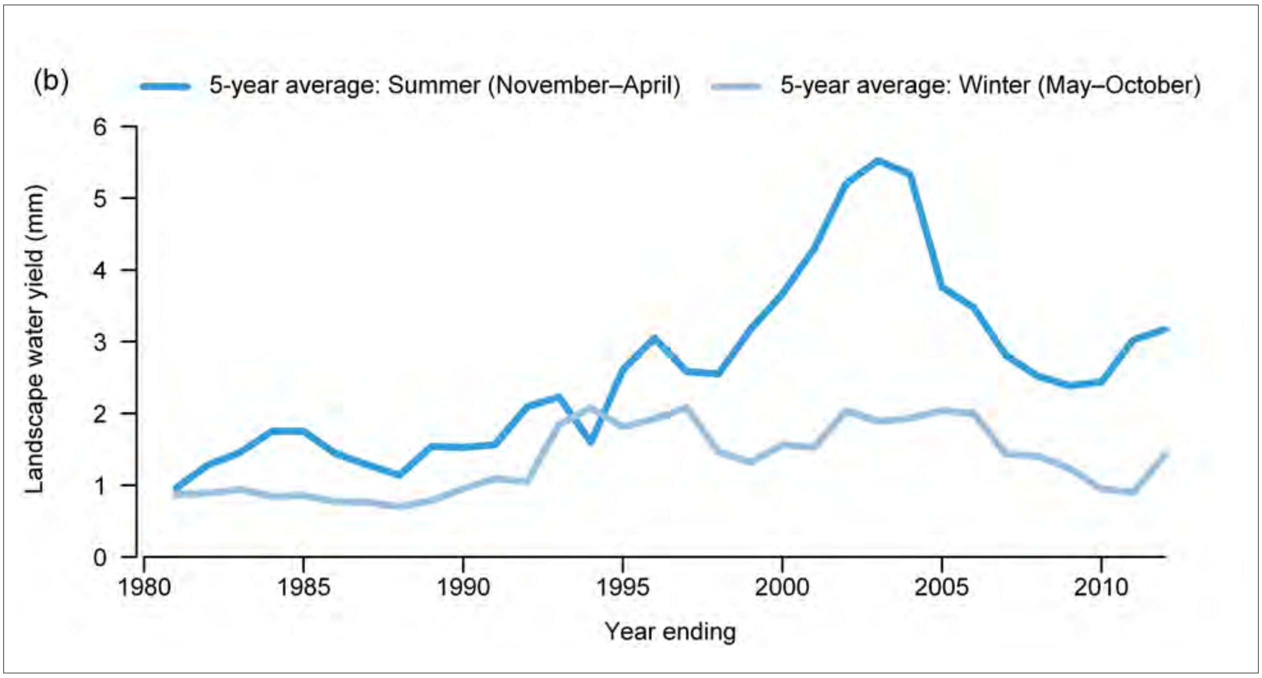




Figure 9.20 Time-series of (a) annual landscape water yield and, (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the South Western Plateau region

### Recent trends in landscape water yield

Figure 9.21a 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 9.21b.

Figure 9.21a shows that, since 1980, trends are marginal, which can be expected when applying linear regression to time-series of particularly low values.

On the other hand, Figure 9.21b shows strongly significant rising trends in landscape water yield in large parts of the region, especially in the centre. The magnitudes of the trends in these areas do not exceed 1 mm/year with most of these areas even having trends below 0.2 mm/year.

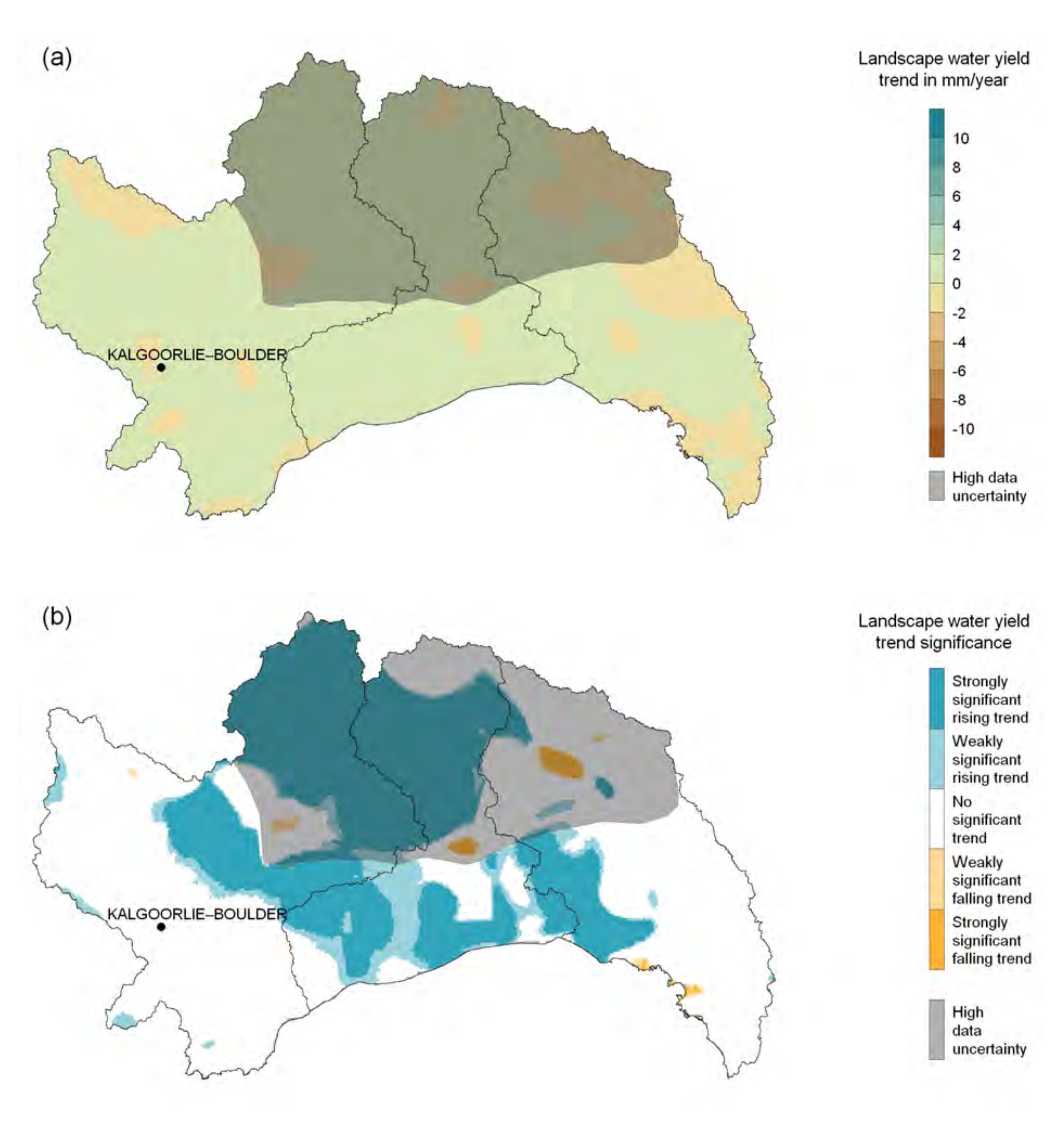



Figure 9.21 Spatial distribution of (a) trends in annual landscape water yield from 1980–2012 and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the South Western Plateau region

# 9.5 Surface water and groundwater

This section examines surface water and groundwater resources in the South Western Plateau region. Rivers and wetlands are discussed to illustrate the region's surface water resources.

The region's watertable aquifers and salinity are described. No data was available at the Bureau in a suitable format for a detailed analysis on individual aquifers.

Due to the absence of suitable data on river flows in this region, no analysis is performed on streamflow characteristics and wetland inflows.

There are no major public storages present in the region.

## 9.5.1 Rivers

There are three river basins in the South Western Plateau region, varying in size from 278,000–496,000 km$^2$. These river basins are Gairdner, Nullarbor and Salt Lake (Figure 9.22).

A substantial number of predominantly dry lakes are present in the west and east of the region as well as more sporadically in the north.

Some small rivers, near Esperance in Western Australia and Ceduna in South Australia, discharge to the Southern Ocean. All streams flow only after heavy rains, which may be two or three or even ten years apart.

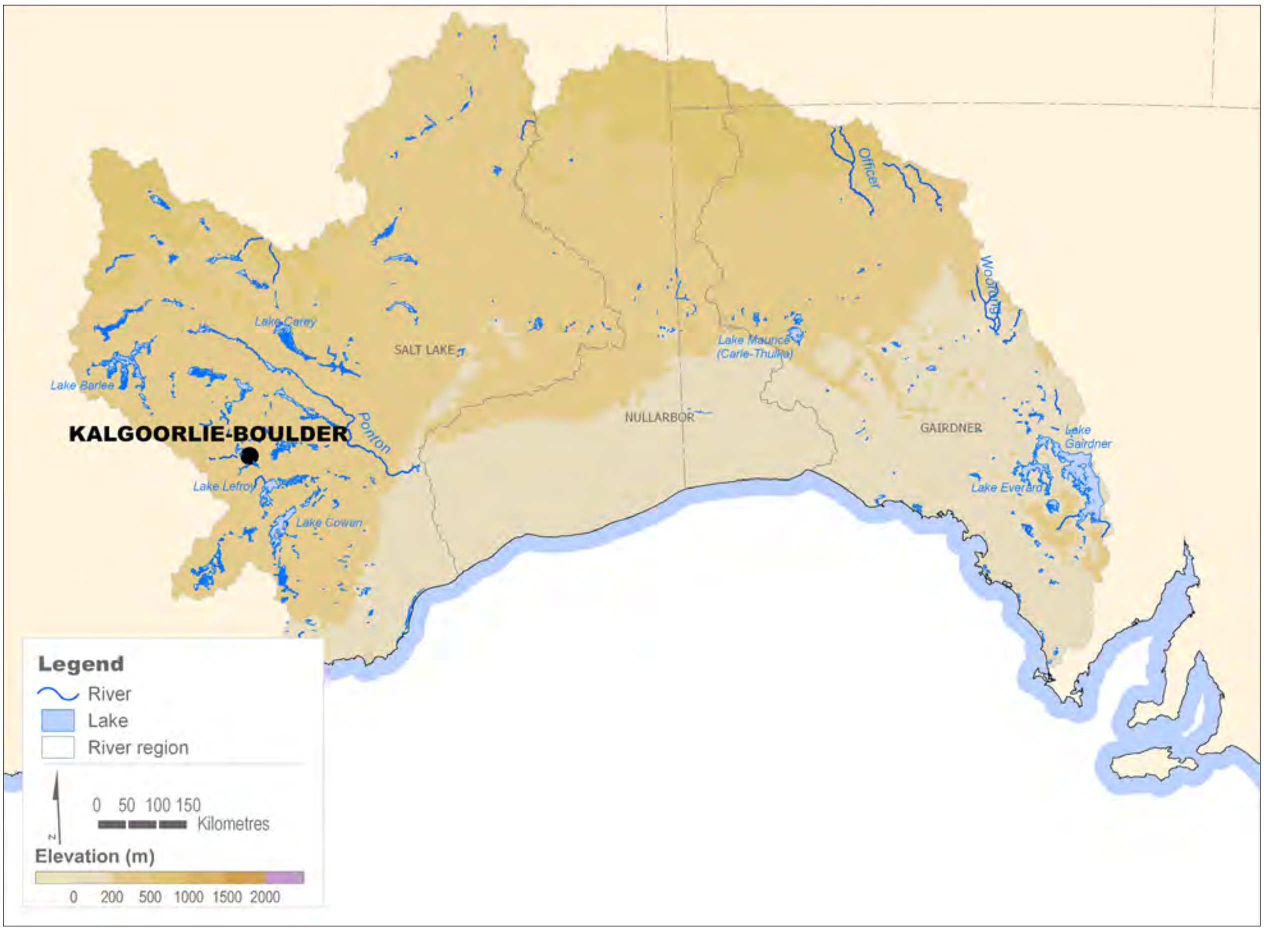



Figure 9.22 Rivers and catchments in the South Western Plateau region

### 9.5.2 Flooding

No major, moderate or minor floods were recorded at the two available Bureau flood monitoring sites near Esperance.

### 9.5.3 Wetlands

The wetlands vary from coastal floodplains and tidal flats to inland ephemeral lakes and large salt lakes. There is one Ramsar-listed, internationally important wetland present in the South Western Plateau region and a number of national important wetlands as shown in Figure 9.23.

The wetlands vary from coastal floodplains and tidal flats to inland ephemeral lakes and large salt lakes.

The Ramsar-listed Lake Warden system near Esperance consists of saline lakes and marsh areas separated from the ocean by sand dunes. It is an important habitat for water birds. More information about the region's wetlands is available from the *Australian Directory of Important Wetlands* (www.environment.gov.au/water/topics/wetlands/database/diwa.html).

No detailed assessment on the inflows of selected wetlands has been performed for this region.

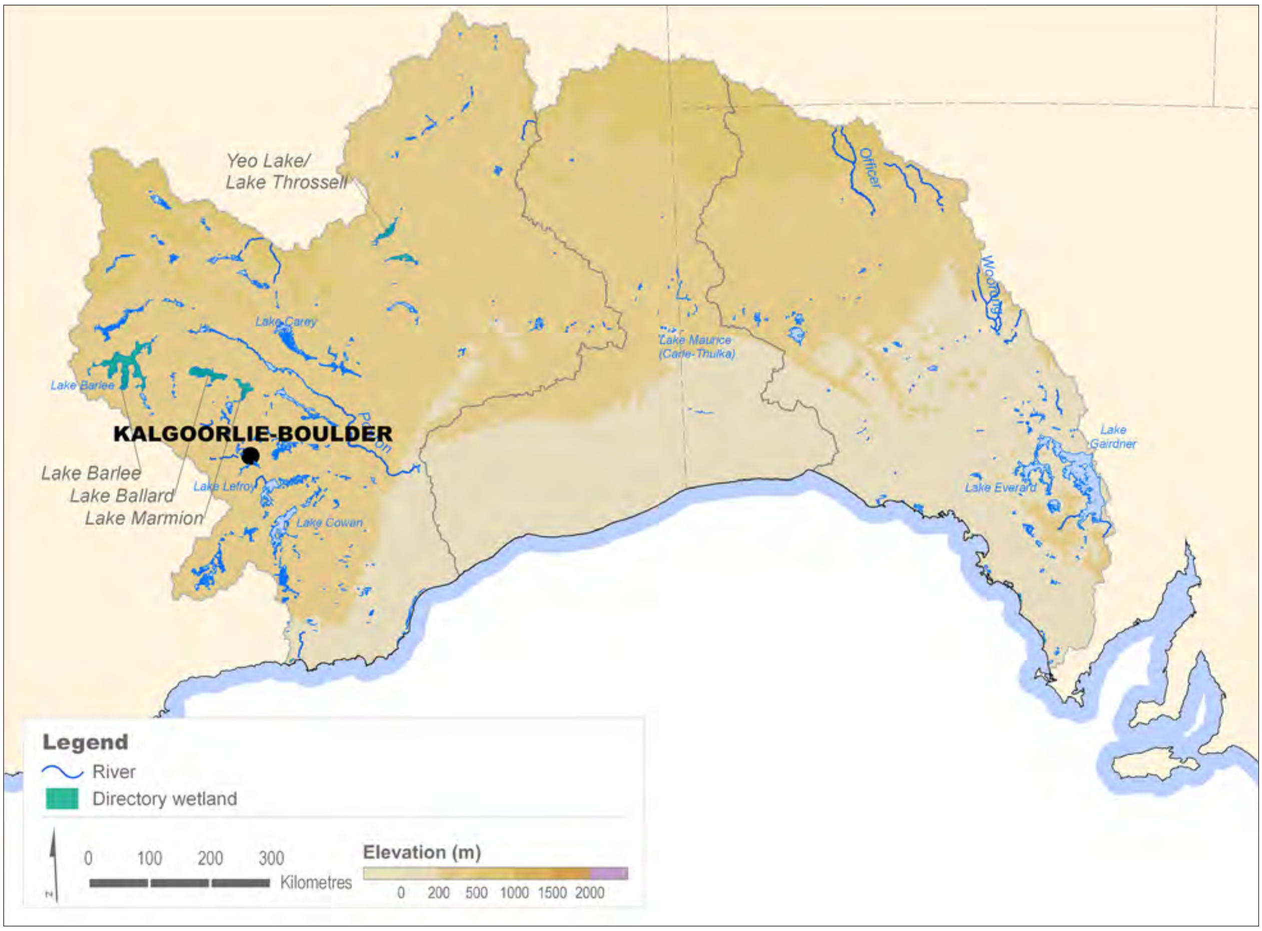



Figure 9.23 Location of important wetlands in the South Western Plateau region

## 9.5.4 Hydrogeology

The hydrogeology of the South Western Plateau region is dominated by a large area of outcropping fractured basement rock (Figure 9.24).

The groundwater systems in fractured rock typically offer restricted low volume groundwater resources. In contrast, there are significant groundwater resources in localised sedimentary aquifers.

Figure 9.24 shows a discontinuity in aquifers across the State border, which is the result of two different State-based aquifer classification systems.

Groundwater systems that provide potential for extraction are labelled as:

- Surficial sediment aquifer (porous media—unconsolidated); and
- Upper mid-Tertiary aquifer (porous media—unconsolidated).

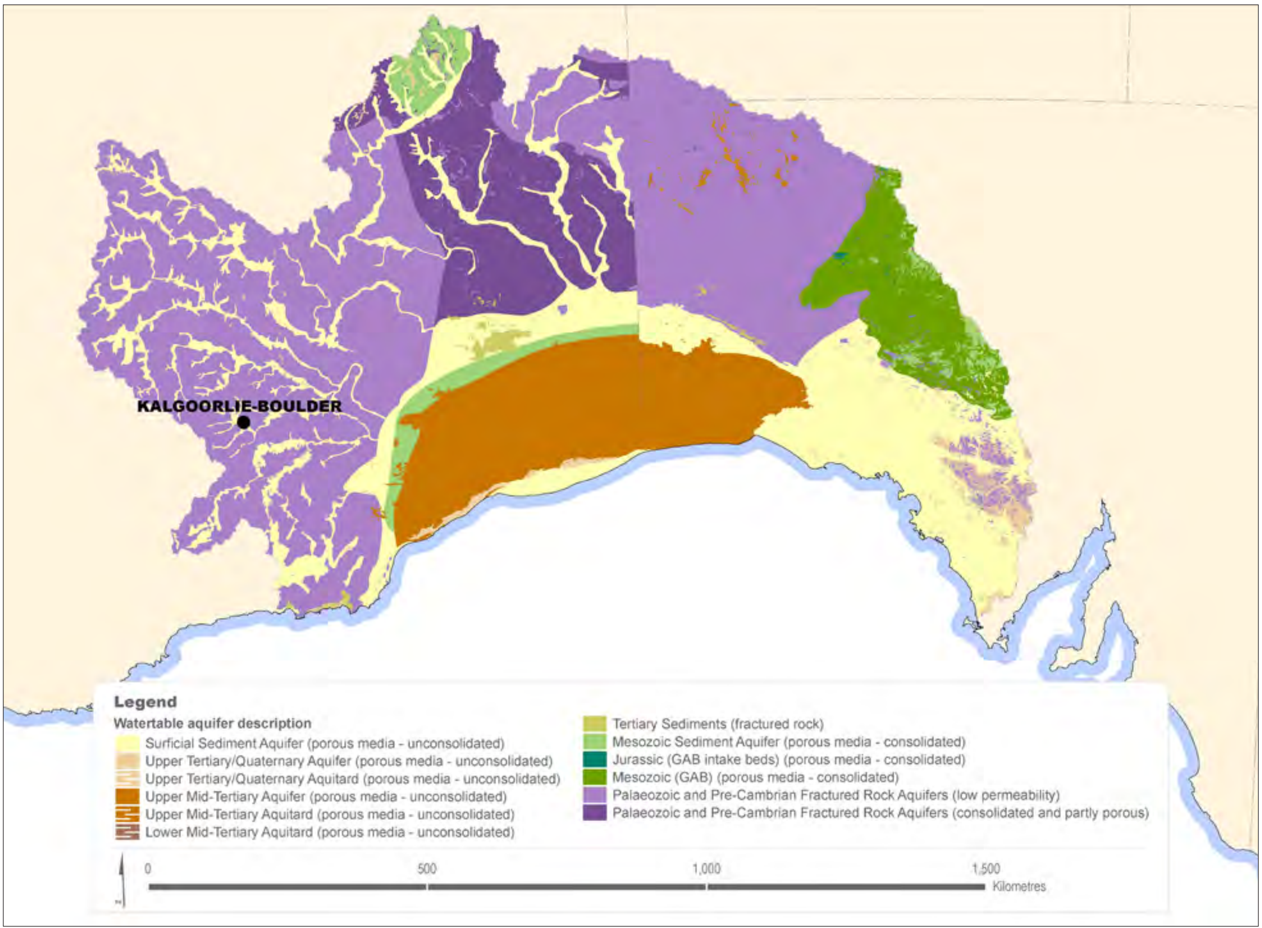



Figure 9.24 Watertable aquifers of the South Western Plateau region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

### 9.5.5 Watertable salinity

Figure 9.25 shows the classification of watertable aquifers as fresh (total dissolved solids [TDS] < 3,000 mg/L) or saline (TDS ≥ 3,000 mg/L) water according to watertable salinity. The discontinuity in aquifers across the State border in Figure 9.25 is the result of two different State-based aquifer salinity classification systems.

Shallow groundwater has been classified mainly as saline within South Australia and around half fresh and half saline in Western Australia; however, a clear pattern of high groundwater salinity is present in the low-lying areas, in particular in those aquifers that are mentioned as having high extraction potential.

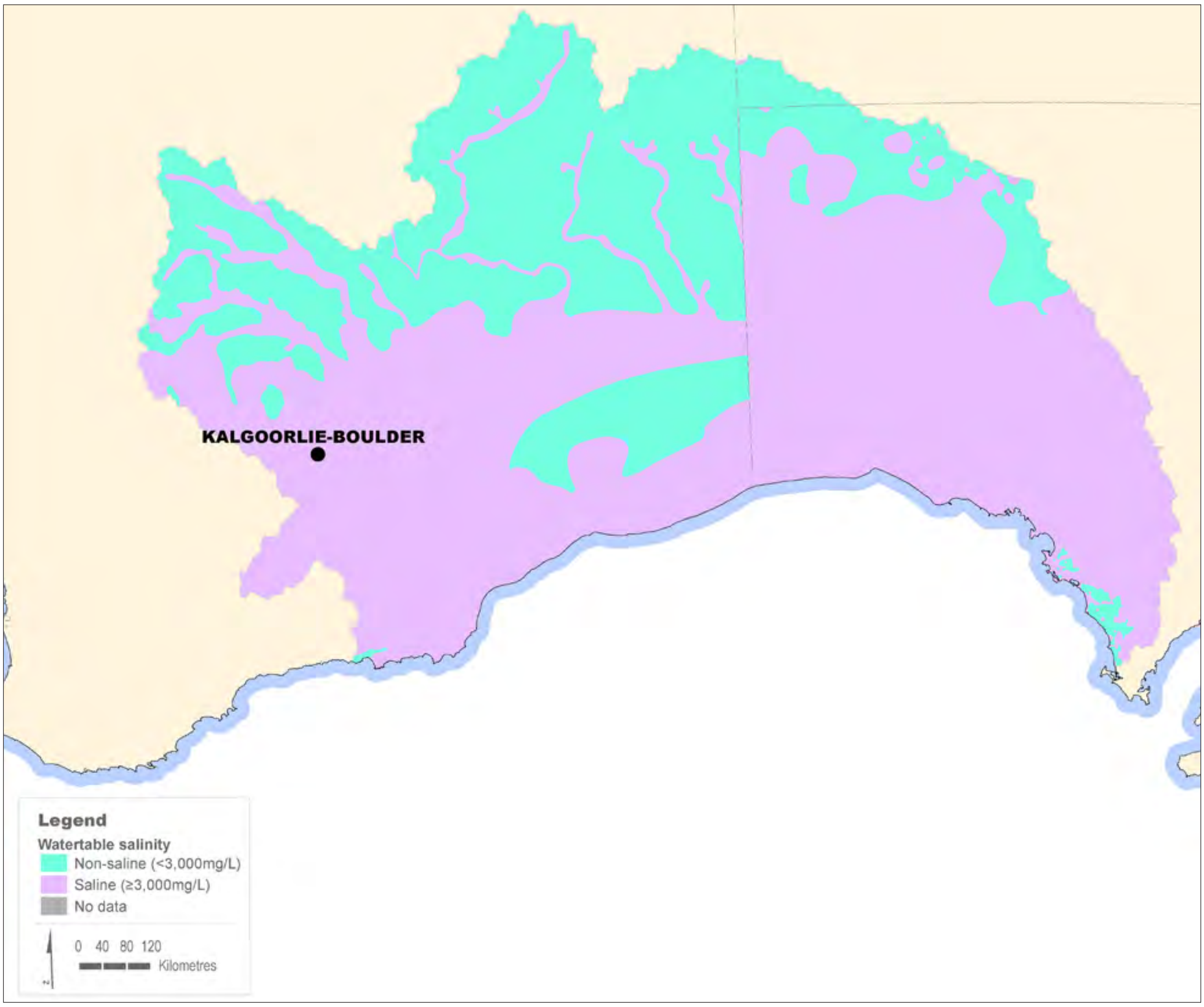



Figure 9.25 Watertable salinity classes of the South Western Plateau region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

### 9.5.6 Groundwater management units

The groundwater management units within the South Western Plateau region are key features that control the extraction of groundwater through planning mechanisms.

The groundwater management units within the region are presented in Figure 9.26. This dataset is extracted from the National Groundwater Information System (2013) which contains a collection of groundwater management units from all States.

The major management units with significant groundwater use include Goldfield, East Murchison, Nullarbor in Western Australia and Musgrave in South Australia.

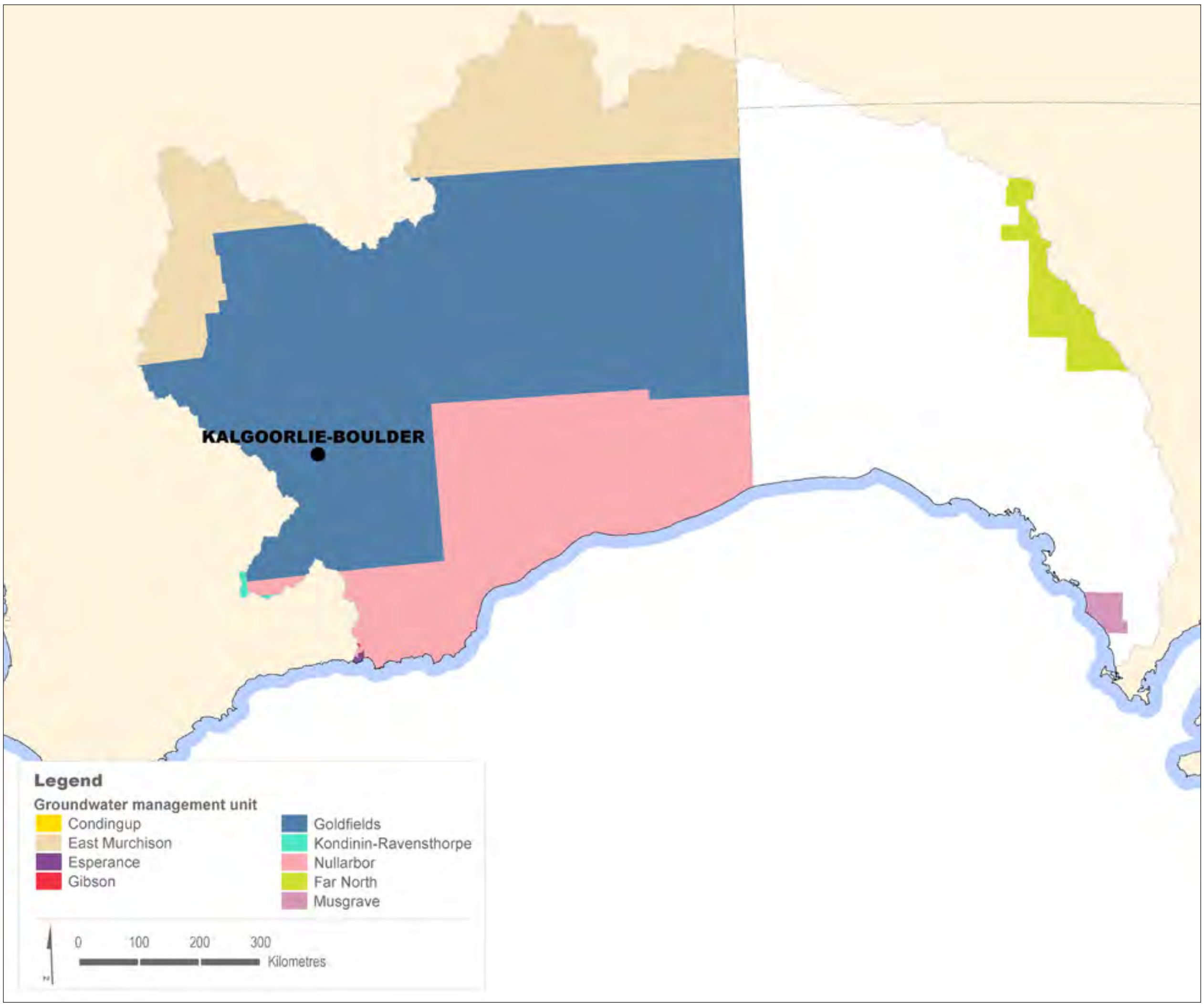



Figure 9.26 Groundwater management units in the South Western Plateau region; data extracted from the National Groundwater Information System (Bureau of Meteorology 2013)