# Technical supplement


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## 1 Introduction

The *Australian Water Resources Assessment 2012* (the 2012 Assessment) is the second in a series of reports produced by the Bureau of Meteorology (the Bureau). The report presents assessments of Australia's climate and water resources in 2011–12 (July 2011– June 2012) and discusses regional variability and trends in water resources and patterns of water use over recent years and decades, based on the currently accessible data.

This Technical Supplement provides supporting information for the 2012 Assessment and includes:

- Region boundaries
- Landscape water balance framework
- Methods summaries
- Data sources and analyses
- Data available with the report.

## 2 Region boundaries

Similar to the 2010 Assessment, the 2012 Assessment is structured around 13 regions covering the Australian continent, based on drainage division boundaries. Drainage divisions represent the catchments of major surface water drainage systems, generally comprising a number of river basins. Drainage divisions provide a natural framework for assessing hydrological flows in the landscape while also allowing information to be presented and discussed in broadly identifiable regional and climatic contexts.

The 13 regions were derived from the Australian Hydrological Geospatial Fabric (Bureau 2011f). This is a specialised geographic information system that identifies the spatial relationships of important hydrological features such as rivers, lakes, reservoirs, dams, canals and catchments.

Hierarchically-nested catchments were derived using an automated drainage analysis procedure based on a nine-second digital elevation model (Bureau of Meteorology 2010c); 12 drainage divisions were defined at the highest level of the hierarchy and were used as the basis for the reporting regions in the 2012 Assessment. This work builds on and approximates the drainage boundaries developed by Geoscience Australia (1997) that were the result of a joint State, Territory and Australian Commonwealth Government project to create a national spatial database of major hydrological basins.

One of the drainage divisions developed by Geoscience Australia, the South East Coast, was split in two, using selected catchment boundaries at the second level of the hierarchy. This division was chosen to best approximate the border between New South Wales (NSW) and Victoria (Victoria), creating the 'South East Coast (NSW)' and 'South East Coast (Vic)' regions.

The differences between the original Geoscience Australia boundaries and those used in the 2012 Assessment are illustrated in Figure 1.

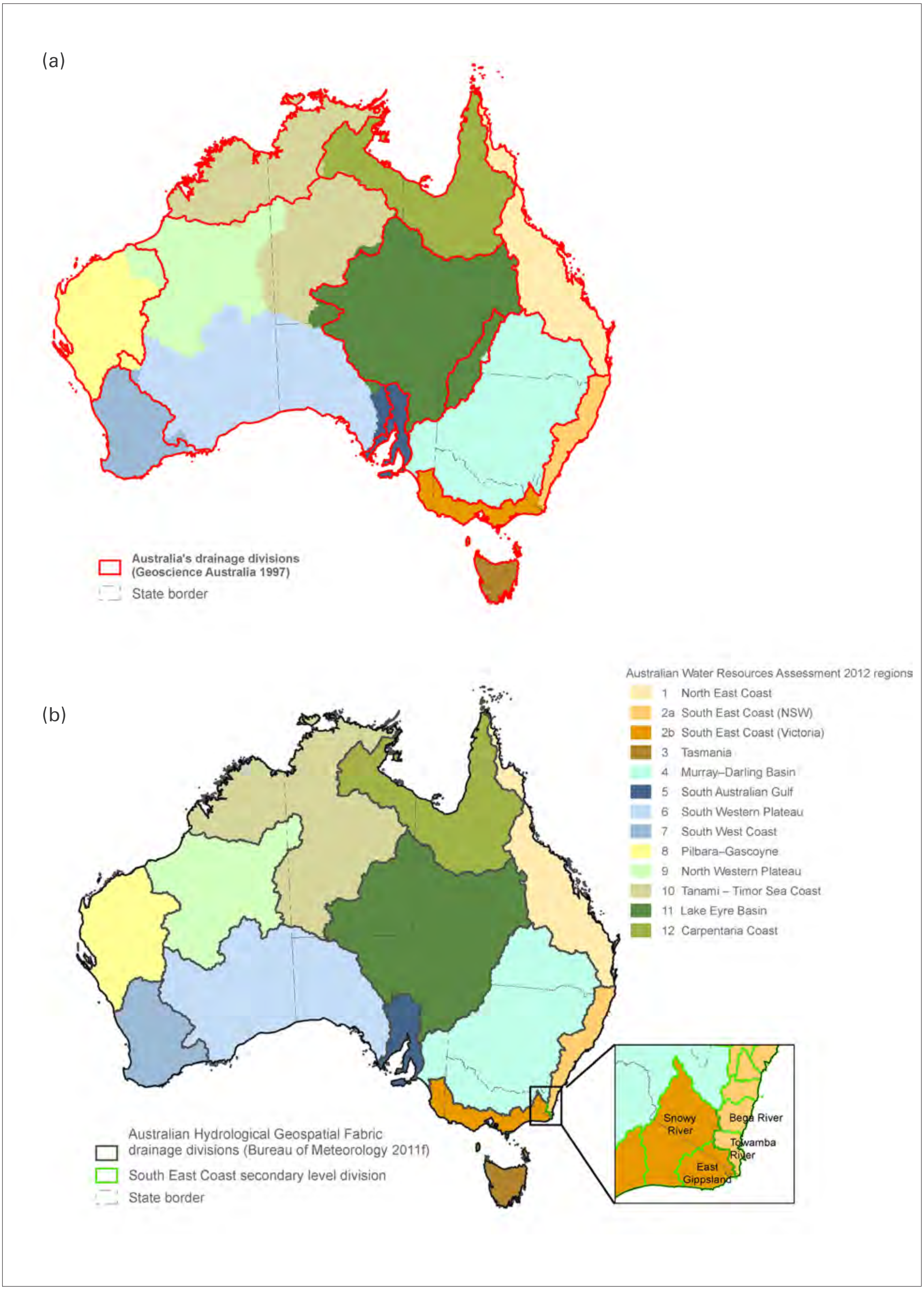


Figure 1 (a) Comparison of drainage division boundaries of Geoscience Australia (1997) and the 2012 Assessment regions, and (b) the subdivision of the South-East Coast drainage division into two reporting regions

# 3 Landscape water balance framework

## 3.1 Background

The estimation of the dominant landscape water flows and stores on a national scale is a major part of the 2012 Assessment. This includes information on precipitation, actual evapotranspiration, soil moisture and landscape water yield (comprising run-off and groundwater discharge). These components are not measured directly. To generate this information across all parts of Australia, modelling simulations and spatial interpolation techniques were used.

This chapter explains the reasoning for the choice of the methods to estimate the spatial and temporal variability of these non-measured water balance components.

### Considerations for choice of the methods

The Bureau's Water Information Services branch was formed in 2008 to produce various retrospective water reporting products. Since then, Bureau and CSIRO staff have been working on establishing systems and methods to support this new role. Two major information products are being produced. These are the Australian Water Resources Assessment (www.bom.gov.au/water/awra) and the National Water Account (www.bom.gov.au/water/nwa).

The National Water Account contains water accounting reports for nationally significant regions. It provides information on water stores and flows, water rights and water use.

Both products require continental scale water balance estimation. Initial investigations identified the need for a framework, according to which the spatially and temporally distributed information was to be presented. This conceptual water balance framework (Barratt 2008) is illustrated in Figure 2. As observations are not available for all of these stores and flows at sufficient frequency and resolution across the continent, as required by the water balance reporting terms, models or/estimation methods are required.

The methods for estimating components of the water balance for the Australian Water Resources Assessment and the National Water Account are chosen according to the following considerations:

- **Consistency:** the methods could be applied consistently to both products;
- **Timeliness:** the methods could be implemented in time for both product deadlines subject to available Bureau resources; and
- **Robustness:** the methods are demonstrably robust compared with other available methods.

The National Water Account presents a detailed annual water balance for the components as shown in Figure 2, focusing on water use and manageable storage from the surface water and groundwater stores. The Australian Water Resources Assessment only captures the major landscape water flow processes, that is, rainfall, actual evapotranspiration, landscape water yield and soil moisture storage, focusing on water availability and the landscape water flows. The choice of methods for estimating these landscape water flows are discussed, in turn, below.

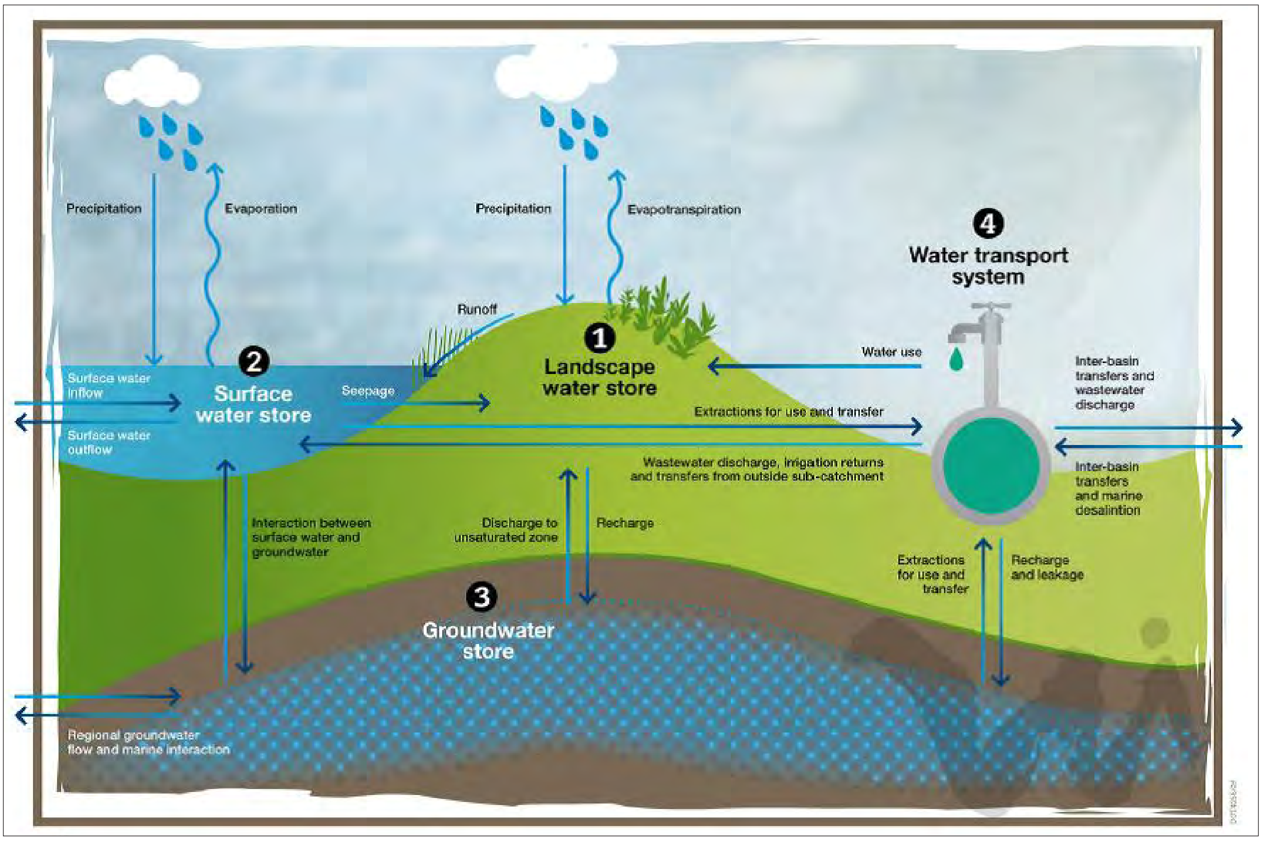


Figure 2 Water flows and stores in the conceptual water balance framework (Barratt 2008)

## 3.2 Measured water balance and climatic data

Rainfall measurements are required for estimation of the spatial distribution of rainfall across Australia and for input into the water balance model. Gridded rainfall estimates produced by the Bureau (Jones et al. 2009) were used. The dataset was derived from spatial interpolation of available daily rainfall readings collected by the Bureau.

Solar radiation and temperature also serve as input into water balance model. Daily gridded estimates provided under the Australian Water Availability Project (AWAP) were used (see www.bom.gov.au/jsp/awap/).

## 3.3 Modelled landscape water balance estimates

The 2010 Assessment included estimates of actual evapotranspiration, landscape water yield (run-off and groundwater discharge) and soil moisture storage from a combination of two conceptually similar models: WaterDyn and AWRA-L. The 2012 Assessment has moved away from that approach to continue with an updated version of the AWRA-L model only. The AWRA-L model version 2.0 (the 2010 Assessment used AWRA-L version 0.5) has been used to produce estimates of the major landscape water flow processes of actual evapotranspiration, landscape water yield and soil moisture storage. Figure 3 shows a diagram of the conceptual processes contained in this model.

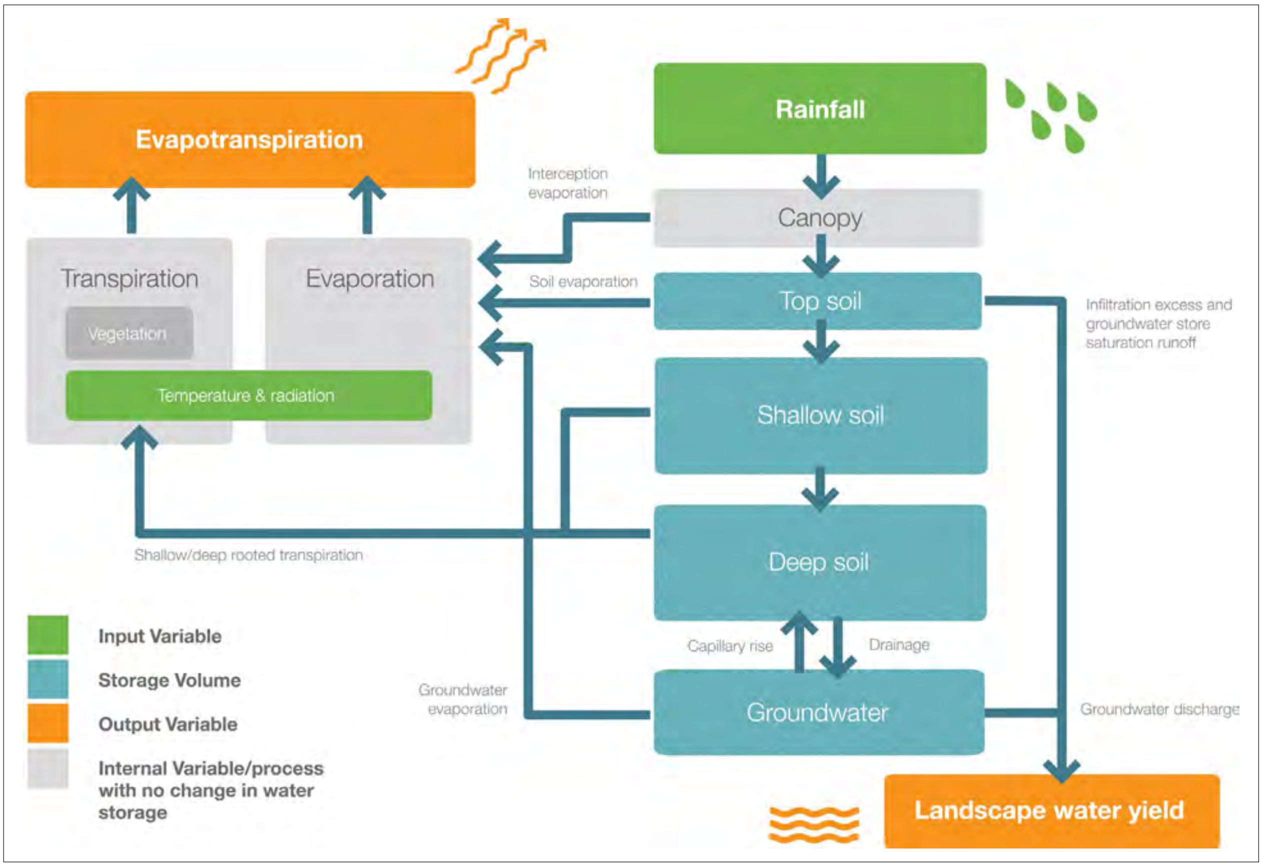


Figure 3 Conceptual diagram of AWRA-L model processes

The choice is based on the fact that the Bureau, in collaboration with CSIRO, is in the process of implementing a holistic water balance model and data assimilation system (named as the AWRA System) which consists of the AWRA-L landscape model, complemented in the future by river and groundwater model components (Figure 4). Already at this stage, but even more so in the future, this system will provide a consistent water balance estimation system, which will be the cornerstone of the Australian Water Resources Assessment and National Water Account products.

The AWRA modelling system will eventually include the following components:

- A holistic **water balance** model (AWRA-LRG)
- A **model-data fusion system** to update and constrain model estimates according to observations where appropriate. Model-data fusion includes calibration/ parameterisation of model components (for example, calibration of a rainfall run-off model according to streamflow data), assimilation of observations to update model states/parameters (updating model soil store states according to satellite observations) and other blending methods (for example, averaging differing model estimates of run-off).
- A **benchmarking system** to test that the model and input data are accurately reflecting observations. The benchmarking system refers to a set of (partly or wholly automated) tests designed to assess how well the simulations from a modified system version (in comparison to a previous system version) reproduce a standard set of observations following a standard set of criteria. This also needs to include ongoing evaluation of system forcing data where possible.

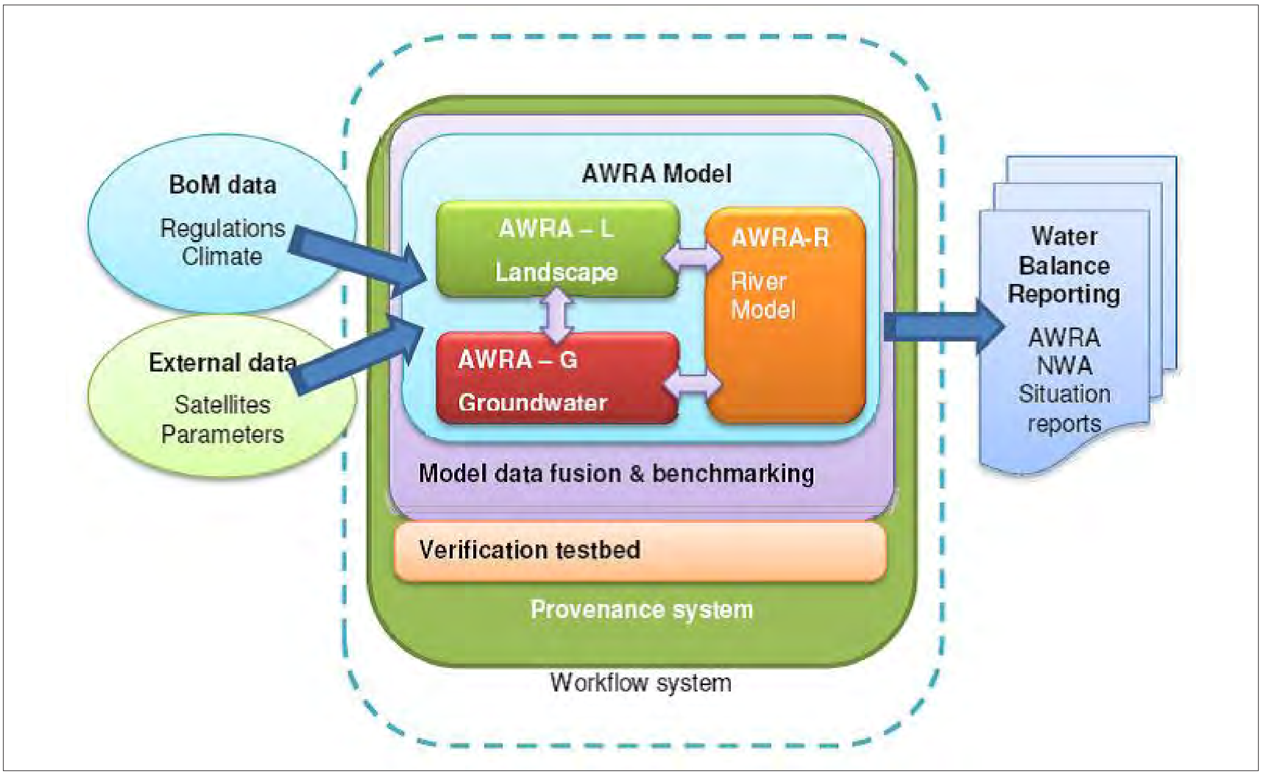


Figure 4 Australian Water Resources Assessment modelling system conceptual diagram

## 3.4 Model performance

The introduction of a sophisticated calibration and verification structure in the last year have enhanced the reliability of the AWRA-L model outcome using AWRA-L v2.0 compared to the combination of models that was used in the 2010 Assessment (that is, average of AWRA-L v0.5 and WaterDyn).

The model calibration and validation structure optimises the reprodution of streamflow and Leaf Area Index (LAI). LAI is a measure of leaf growth and is estimated using satellite imagery. The LAI is included in the objective function of the calibration procedure to improve the model's capacity to reflect vegetation growth. Vegetation growth plays an important role in the generation of transpiration, which in turn forms a large part of the actual evapotranspiration that is reported on in the 2012 Assessment.

The calibration of model parameters to optimise streamflow reproduction is done to improve the model's estimates on landscape water yield. In the calibration procedure, the landscape water yield totals of all grid cells in the catchment are combined to form streamflow at the gauging point of a catchment.

Figure 5 indicates model performances in estimating streamflow throughout Australia with a single parameter set. The results of the model are compared with previous versions of the model as well as the previously used (single parameter set) WaterDyn model. To indicate achievable model performances a purpose specific rainfall run-off model (CWYET_GR4J) is also included in this comparison.

Nash–Sutcliffe model efficiency coefficient (NSE) and the relative bias are used as measures of the predictive strength of these models (Figure 5). The higher the NSE and the lower the bias, the better the match between the model results and the observations.

The CWYET_GR4J model results given in Figure 5 are estimated on the basis of using calibrated parameter sets of neighbouring catchments. The AWRA-L model on the other hand uses one parameter set for the whole country.

The introduction of the advanced calibration tool (in AWRA-L v1.0) particularly helped improving the AWRA-L model results. Since then, minor improvements have been achieved mainly through the introduction of additional information, in particular on vegetation, from remotely sensed products and small conceptual changes in some components of the model.

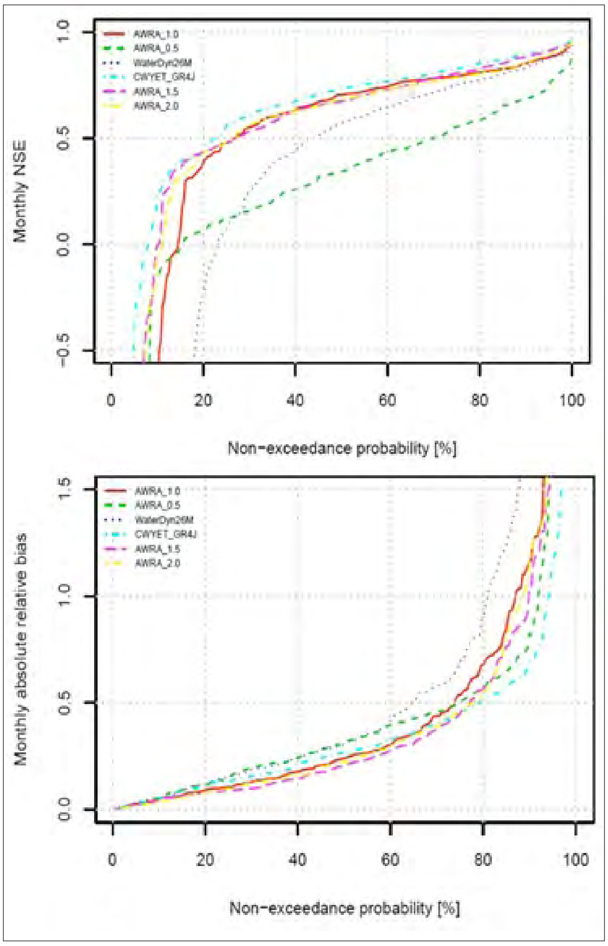


Figure 5 Distribution of the Nash-Suthcliff Efficiency (NSE) scores and relative bias for monthly streamflow reproduction of 289 catchments

# 4 Methods summaries

The 2012 Assessment includes many different analysis methods, most of them specifically focusing on particular components of the water resources (that is, groundwater, reservoirs or streamflow). These methods were carefully selected based on a sound investigation of similar assessments previously performed in Australia and overseas.

The tables that follow provide a list of references and peer reviews of each of the methods used, so as to demonstrate their validity. For each method the following information is provided:

- a reference to the section in which the method is used;
- a short description of the input data for the analysis;
- a short description of the applied method;
- the resolution (temporal and spatial) of the output data;
- references to other work in which the method was applied; and
- an example illustration of the output.

In addition to this, information on each individual report figure can be found in the metadata for the figure in question. This is provided on the Australian Water Resources Assessment website: www.bom.gov.au/water/awra/

| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Annual and monthly national rainfall surfaces**<br>Landscape water flows in 2011–12, National Overview, s. 2.3 | **Description**<br>5 km x 5 km original rainfall grid data derived using an anomaly-based approach applying the Barnes successive correction method and smoothing spline approach.<br>**Source**<br>Bureau (National Climate Centre) | **Description**<br>Bureau standard spatial climate data presentation method. Monthly and annual total rainfall grids (July–June) presented.<br>Resolution of output<br>Temporal: annual / monthly<br>Spatial: 5 km x 5 km grid (national coverage) | Bureau of Meteorology 2012, *Annual Climate Summary 2011*, www.bom.gov.au/climate/annual_sum/2011/index.shtml<br>Jones, DA, Wang, W, Fawcett, R  2009, 'High-quality spatial climate data-sets for Australia', *Australian Meteorological and Oceanographic Journal, vol. 58*, pp. 233–48 |

| Example figures |
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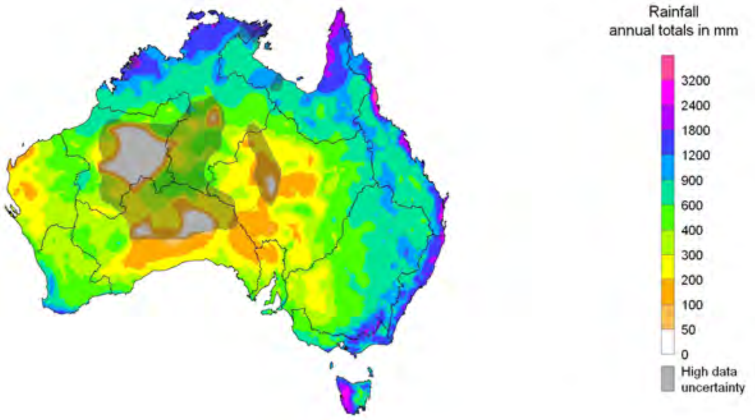
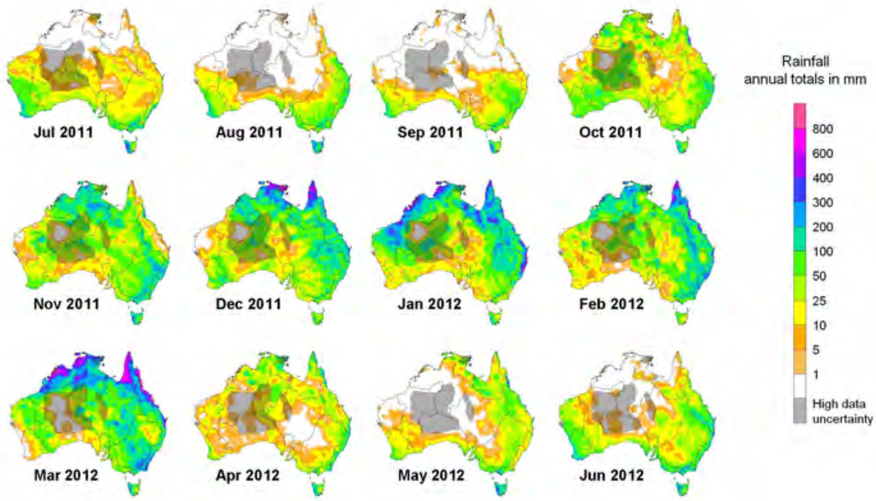
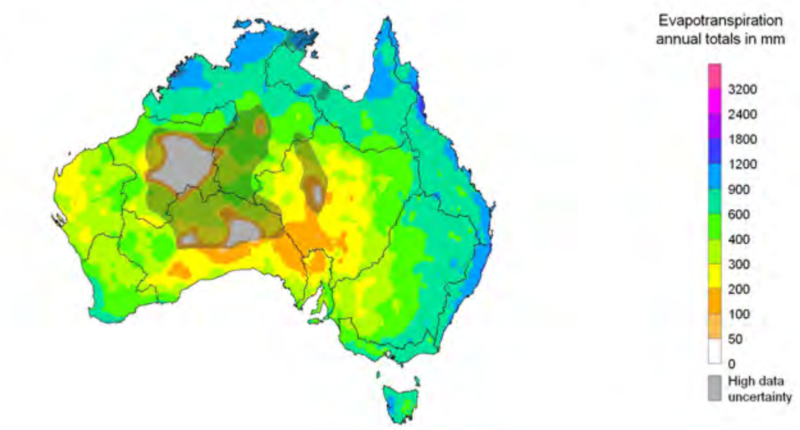
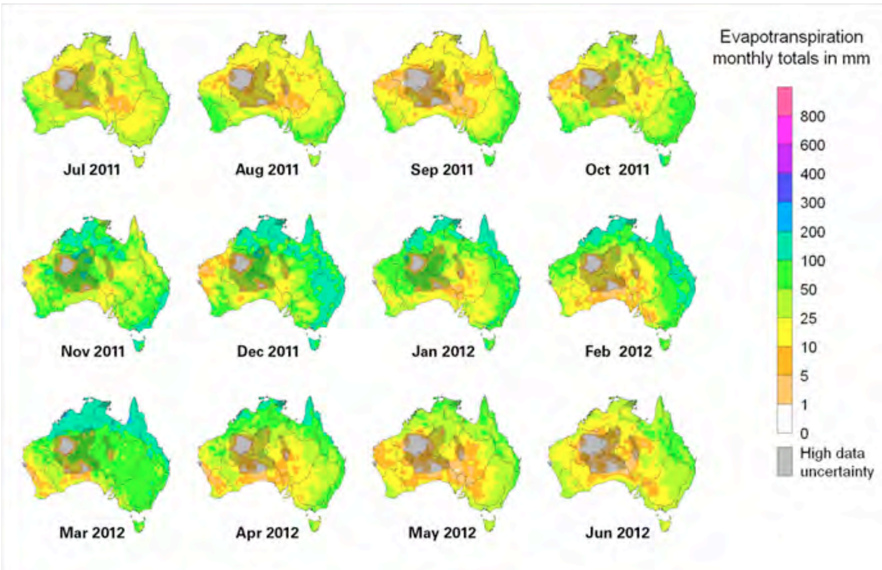


| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Annual and monthly national modelled actual evapotranspiration surfaces**<br>Landscape water flows in 2011–12, National Overview, s. 2.3 | **Description**<br>5 km x 5 km actual evapotranspiration grid data, based on the Priestly–Taylor equation.<br>**Source**<br>AWRA-L 2.0 | **Description**<br>Bureau standard spatial climate data presentation method. Monthly and annual total modelled actual evapotranspiration grids (July–June) presented.<br>**Resolution of output**<br>Temporal: annual / monthly<br>Spatial: 5 km x 5 km grid (national coverage) | Van Djik A 2010, The Australian Water Resources Assessment system, Technical report 3, Landscape model, version 0.5, *Water for Healthy Country*, CSIRO National Research Flagship, www.clw.csiro.au/publications/waterforahealthycountry/2010/wfhc-aus-water-resources-assessment-system.pdf |

## Example figures



| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Annual and monthly national modelled landscape water yield surfaces**<br>Landscape water flows in 2011–12, National Overview, s. 2.3 | **Description**<br>5km x 5 km modelled landscape water yield grid data.<br>**Source**<br>AWRA-L 2.0 | **Description**<br>Bureau standard spatial climate data presentation method. Monthly and annual total modelled landscape water yield grids (July–June) presented.<br>**Resolution of output**<br>Temporal: annual / monthly<br>Spatial: 5km x 5 km grid<br>(national coverage) | Van Djik A 2010, The Australian Water Resources Assessment system, Technical report 3, Landscape model, version 0.5, *Water for Healthy Country*, CSIRO National Research Flagship, www.clw.csiro.au/publications/waterforahealthycountry/2010/wfhc-aus-water-resources-assessment-system.pdf<br>Viney, NR 2010, 'A comparison of modelling approaches for continental stream flow prediction', Water for Healthy Country, CSIRO National Research Flagship, CSIRO, Canberra. |

| Example figures |
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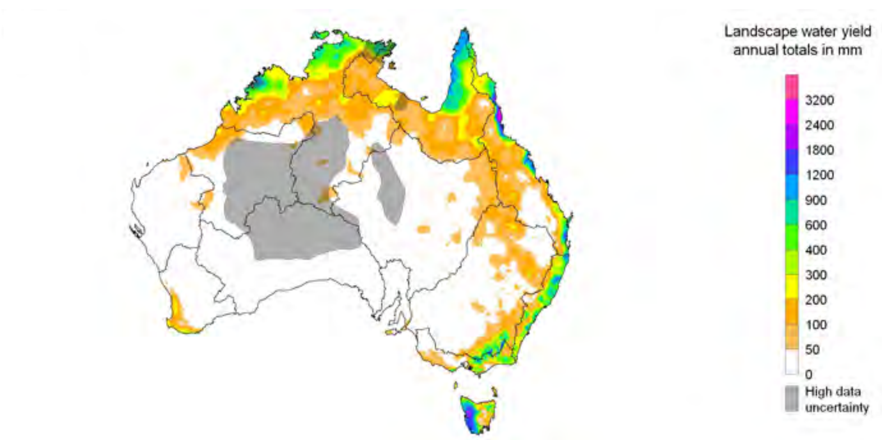
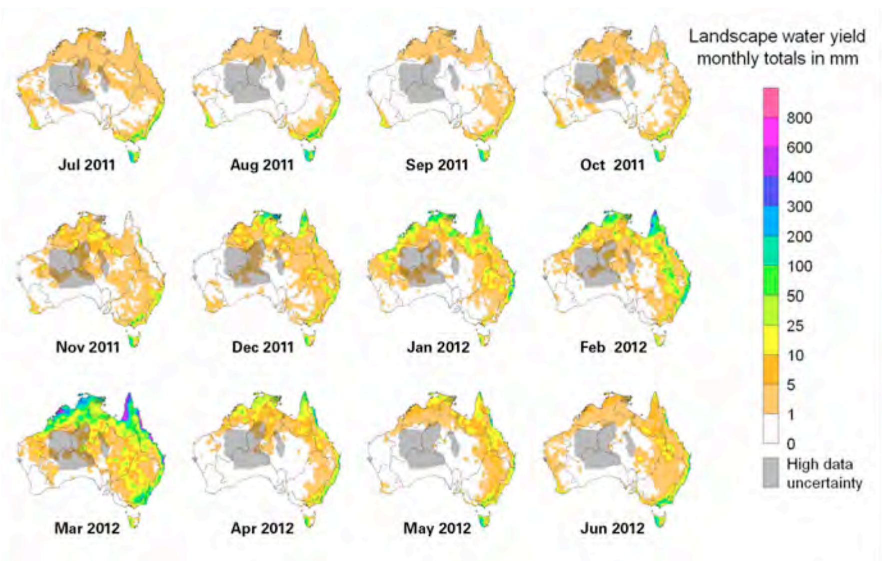
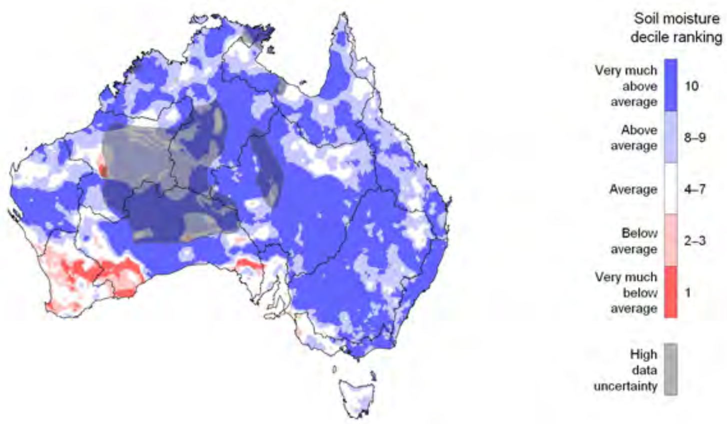
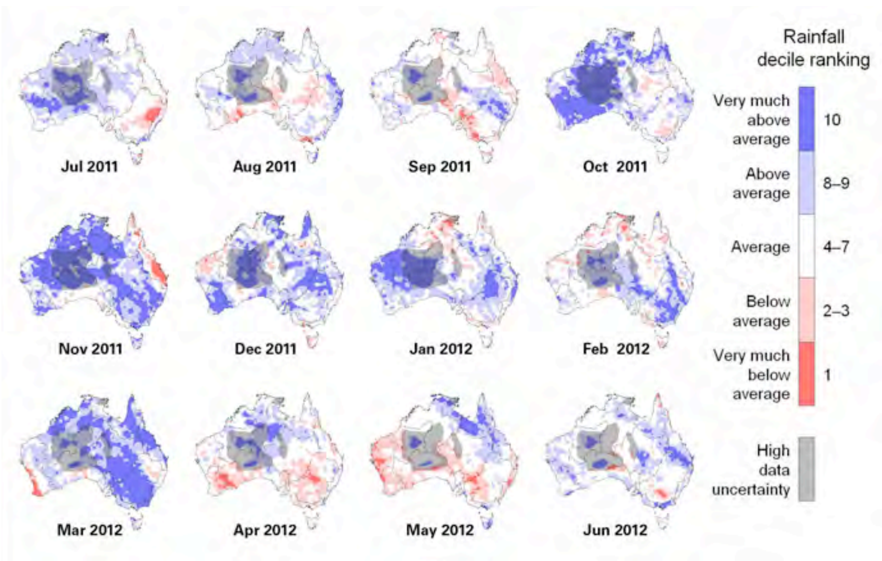


| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Annual and monthly national deciles (rainfall, evapotranspiration and landscape water yield)**<br>Landscape water flows in 2011–12, National Overview, s. 2.3 | **Description**<br>5 km x 5 km annual and monthly deciles grid data generated for each of the landscape water flows.<br>Deciles calculated from long-term gridded data (July 1911–June 2012).<br>**Source**<br>Bureau (National Climate Centre) and AWRA-L 2.0 | **Description**<br>Bureau standard spatial climate data analysis and presentation method. Monthly and annual deciles grids (July–June) presented based on the long-term record (July 1911–June 2012).<br>**Resolution of output**<br>Temporal: annual / monthly<br>Spatial: 5 km x 5 km grid (national coverage) | Bureau of Meteorology 2012, *Annual Climate Summary 2011*, www.bom.gov.au/climate/annual_sum/2011/<br>Bureau of Meteorology 2013, Special climate statements, www.bom.gov.au/climate/current/special-statements.shtml<br>Centre for Australian Weather and Climate Research 2013, www.cawcr.gov.au/publications/researchletters.php |

## Example figures



| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Annual variation in national soil moisture surfaces**<br>Soil Moisture in 2011–12, National Overview, s. 2.4 | **Description**<br>5 km x 5 km gridded annual soil moisture volume data.<br>Deciles calculated from long-term gridded data (July 1911–June 2012).<br>**Source**<br>AWRA-L 2.0 | **Description**<br>Modelled annual average soil moisture deciles for 2011–12 with respect to the 1911–2012 record<br>**Resolution of output**<br>Temporal: annual<br>Spatial: 5 km x 5 km grid (national coverage) | Van Djik A 2010, The Australian Water Resources Assessment system, Technical report 3, Landscape model, version 0.5, *Water for Healthy Country*, CSIRO National Research Flagship, www.clw.csiro.au/publications/waterforahealthycountry/2010/wfhc-aus-water-resources-assessment-system.pdf |

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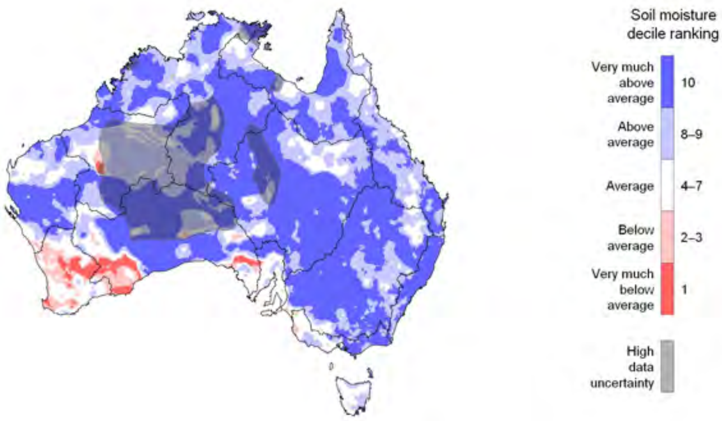
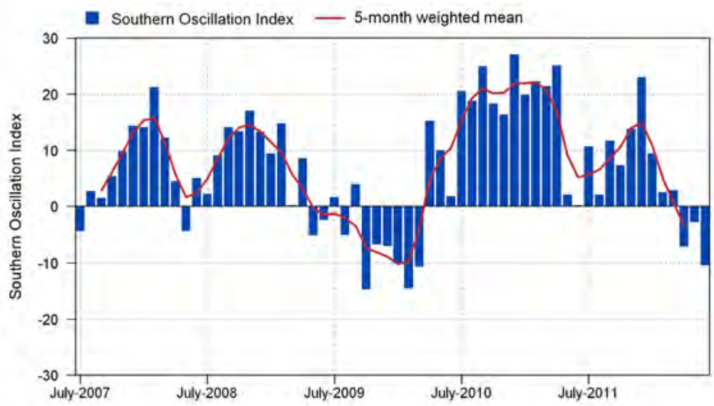
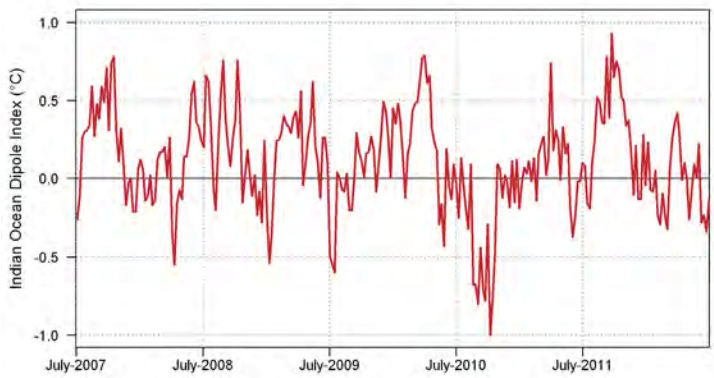
|  |

| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Southern Oscillation Index (SOI) and Indian Ocean Dipole (IOD) time-series**<br>Drivers of the Australian climatic condition in 2011–12, National Overview, s. 2.9 | **Description**<br>Monthly Southern Oscillation Index (SOI) time-series data (July 2007– July 2012).<br>Weekly Indian Ocean Dipole (IOD) time-series data (July 2007–July 2012).<br>**Source**<br>Bureau (National Climate Centre) | **Description**<br>Standard presentation of historic SOI and IOD time-series data.<br>SOI data presented at monthly resolution with a five-month binomial weighted mean. The five-month mean for month x = (SOIx-2 + 4SOIx-1 + 6SOIx + 4SOIx+1 + SOIx+2)/16<br>IOD Index data presented at weekly resolution.<br>**Resolution of output**<br>Temporal: monthly (SOI) and weekly (IOD) | Bureau of Meteorology 2012, 'El Niño / La Niño', ENSO Wrap-Up, www.bom.gov.au/climate/enso/<br>Bureau of Meteorology 2012, SOI and IOD time-series, www.bom.gov.au/climate/current/soi2.shtml, and www.bom.gov.au/climate/enso/indices.shtml<br>Troup, A 1965, 'The southern oscillation', *Quarterly journal of Royal Meteorological Society*, vol. 91, pp. 490–506.<br>Saji, NH et al. 'A dipole mode in the tropical Indian Ocean', Nature, vol. 401, pp. 360–63. |

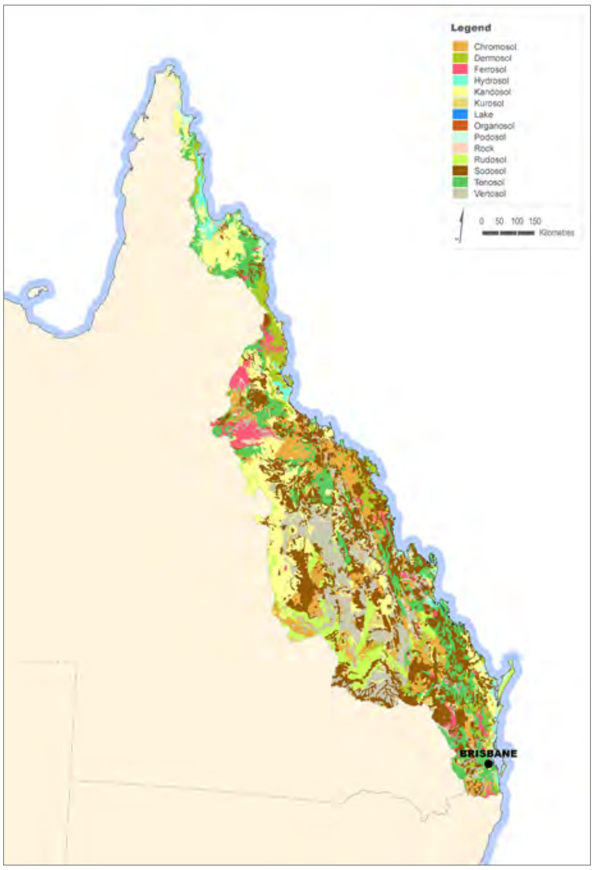
Example figures



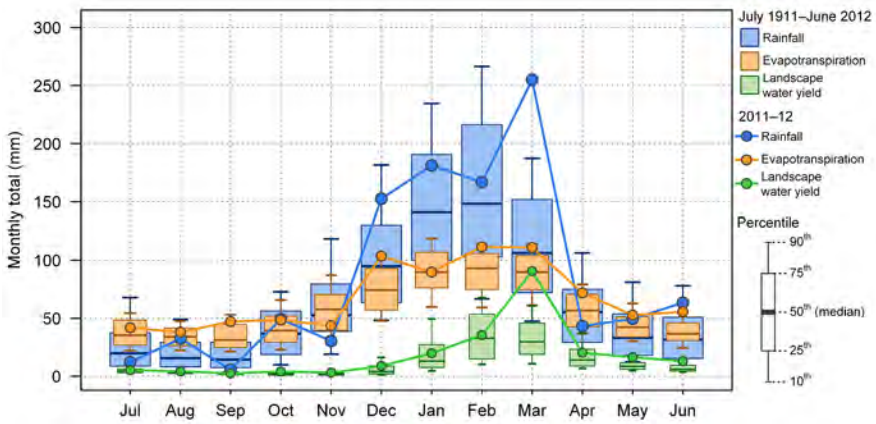
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Soil types**<br>Description of the region, s. 3 of the regional chapters | **Description**<br>The map shows the distribution of soil types as classified per Australian soil order classification system. | **Description**<br>The soil type map was produced by linking digital soil mapping units of the *Atlas Australian Soil Classification* (Northcote et al.1960–1968) to the Australian Soil Classification soil order as developed by Ashton and McKenzie (2001). *The Atlas of Australian Soils* was produced between 1960 and 1968 (Northcote et al. 1960–1968).<br>A digital version of the atlas was created by the Bureau of Rural Science in 1991.<br>The data was accessed through the ASRIS website (ASRIS 2011)<br>The digital soil mapping units are accessible at a scale of 1:2,000,000, but the original compilation was at scales from 1:250,000 to 1:500,000. | Ashton, LJ, McKenzie, NJ 2001, 'Conversion of the Atlas of Australian Soils to the Australian Soil Classification', CSIRO Land and Water (unpublished)<br>CSIRO, Australian Soil Resource Information System 2012, retrieved 7 November 2012, www.asris.csiro.au<br>Northcote, KH et al. 1960–1968, *Atlas of Australian Soils*, sheets 1 –10 (includes explanatory data), CSIRO Australia and Melbourne University Press, Melbourne |

Example figures



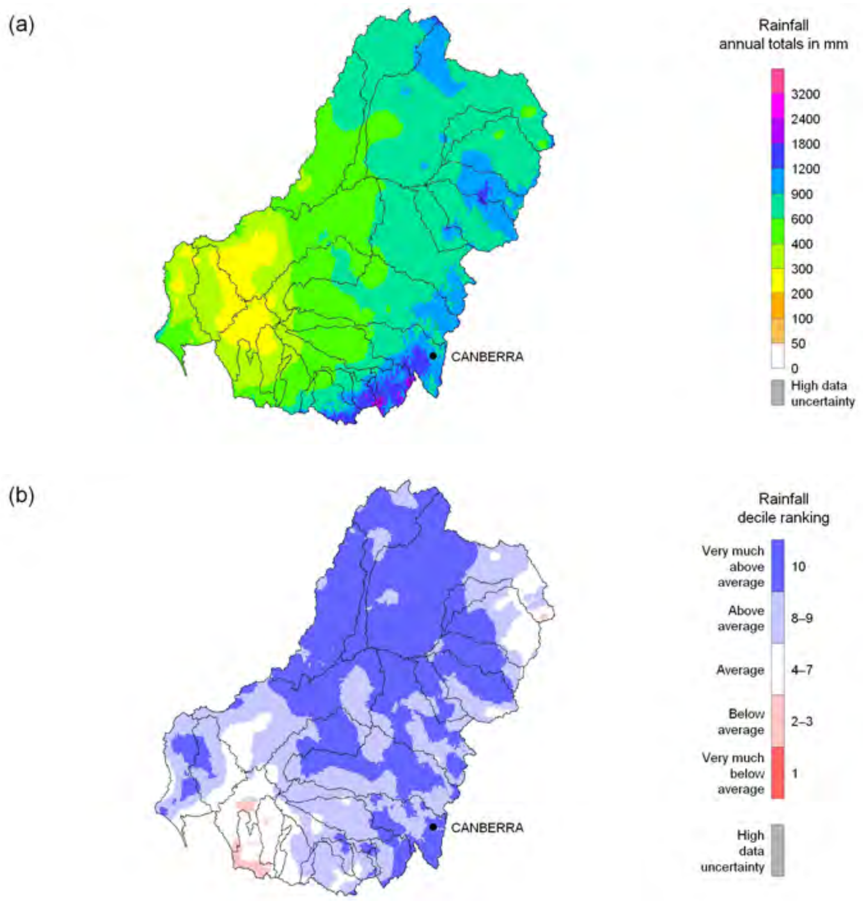
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Monthly box plots of regional landscape water balance model flows**<br>Landscape water flows, s. 4 of the regional chapters | **Description**<br>Regionally averaged monthly landscape water flow data.<br>Data presented are rainfall, evapotranspiration and landscape water yield.<br>**Source**<br>Bureau (National Climate Centre) and AWRA-L 2.0 | **Description**<br>Monthly data for the current year (2011–12) are presented relative to long-term record. Monthly distributions (box and whiskers) are calculated from long-term model run data (July 1911–June 2012).<br>Landscape water flow variables presented are:<br>• rainfall;<br>• actual evapotranspiration; and<br>• landscape water yield.<br>**Resolution of output**<br>Temporal: monthly<br>Spatial: 2012 Assessment reporting region (spatially averaged) | Bureau of Meteorology 2013, 'Example for the interpretation of the Bureau's Streamflow Forecasts', www.bom.gov.au/water/ssf/forecasts.shtml#drainage=murray_darling&basin=upper_murray&catchment=Q_HUME_TOT&productType=DT_1&productGroup=data |

Example figures



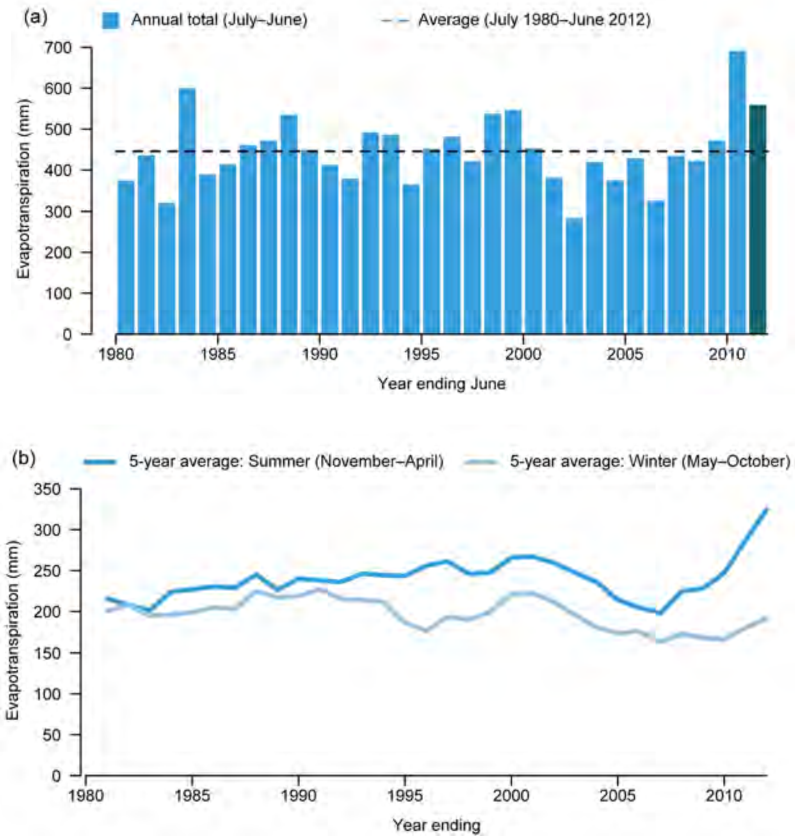
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Regional summary of annual landscape water flows (mapped annual totals and deciles)**<br>Landscape water flows, s. 4 of the regional chapters | **Description**<br>5 km x 5 km gridded annual landscape water flows data (July–June).<br>Deciles calculated from long-term gridded data (July 1911– June 2012)<br>The underlying data are the same as presented for the national overview landscape water flow surfaces in s. 2.3.<br>**Source**<br>Bureau (National Climate Centre) and AWRA-L 2.0 | **Description**<br>Bureau standard spatial climate data presentation method. Annual total and annual deciles landscape water flow grids (July–June) presented.<br>Annual deciles grids<br>(July–June) calculated based on the long-term record (July 1911–June 2012).<br>Landscape water flow variables presented are:<br>• rainfall;<br>• actual evapotranspiration; and<br>• landscape water yield<br>**Resolution of output**<br>Temporal: annual<br>Spatial: 5 km x 5 km grid for each 2012 Assessment reporting region | Bureau of Meteorology 2012, *Annual Climate Summary 2011*, www.bom.gov.au/climate/annual_sum/2011/ |

Example figures



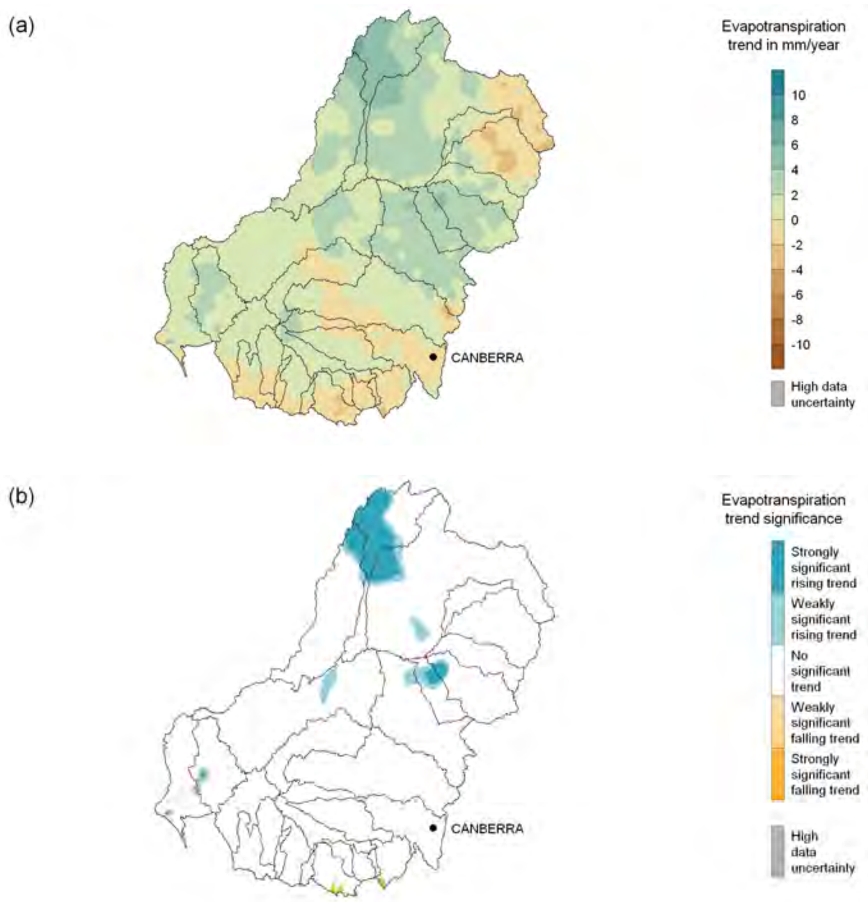
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Time-series of landscape water flows over the past 32 years (annual and seasonal)**<br>Landscape water flows, s. 4 of the regional chapters | **Description**<br>Spatially averaged monthly and annual landscape water flow data (July–June). Summer (November–April) and winter (May–October) season totals calculated from monthly model output data.<br>**Source**<br>Bureau (National Climate Centre) and<br>AWRA-L 2.0 | **Description**<br>Time-series plot of annual data presented for last 32 years (July 1980– June 2012).<br>Time-series plot of seasonal five-year moving averages (backward looking) data presented for last 32 years (November 1980–October 2012).<br>Landscape water flow variables presented are:<br>• rainfall;<br>• actual evapotranspiration; and<br>• landscape water yield.<br>**Resolution of output**<br>Temporal: annual (July–June) and six-month seasons (November–April and May–October)<br>Spatial: 2012 Assessment reporting region (spatially averaged) | Bureau of Meterology 2013, 'Example of the Bureau's climate variability and change time series: Annual plot', Australian climate variability and change —Time series graphs, www.bom.gov.au/cgi-bin/climate/change/timeseries.cgi?graph=rain&area=aus&season=0112&ave_yr=A<br>Bureau of Meteorology 2013, 'Example of the Bureau's climate variability and change time series: Seasonal plot', Australian climate variability and change —Time series graphs, www.bom.gov.au/cgi-bin/climate/change/timeseries.cgi?graph=rain&area=aus&season=0411&ave_yr=5<br>Jones, DA, Wang, W, Fawcett, R 2009, 'High-quality spatial climate data-sets for Australia', *Australian Meteorological and Oceanographic Journal*, vol. 58, pp. 233–48. |

Example figures



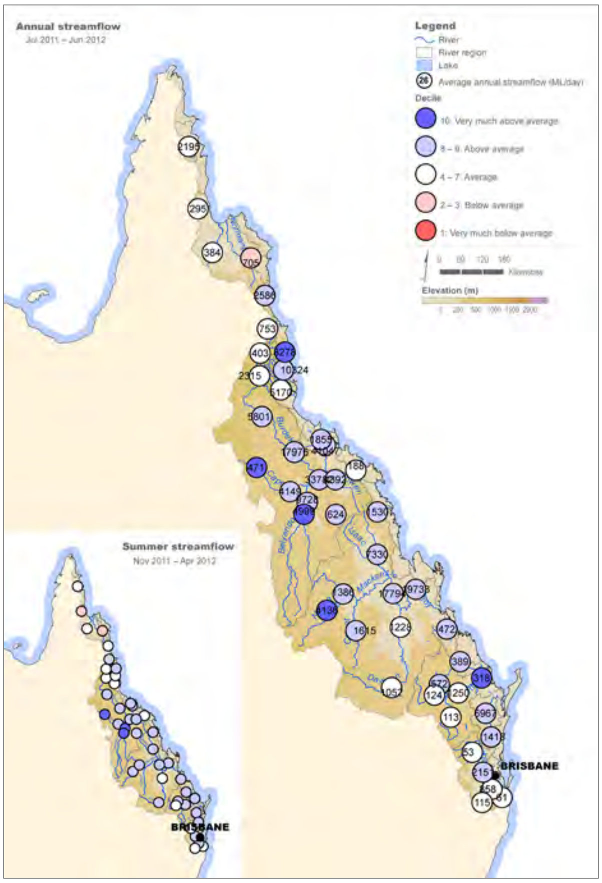
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Regional maps trends in annual landscape water flows over the past 32 years (seasonal)**<br>Landscape water flows, s. 4 of the regional chapters | **Description**<br>5 km x 5 km gridded landscape water flow data.<br>Trend analysis applied to annual totals for the past 32 years (1980–2012).<br>**Source**<br>Bureau (National Climate Centre) and<br>AWRA-L 2.0 | **Description**<br>Linear regression trend calculated for annual totals at each 5 km x 5 km grid cell over the last 32 years (July 1980–June 2012). Slope of linear regression line (mm/year) reflects the strength and direction of potential trends.<br>The significance test (t-test) for the slopes of the regression lines at 5% (strongly significant) and 10% (weakly significant) was calculated.<br>**Resolution of output**<br>Temporal: annual<br>Spatial: 5 km x 5 km grid for each 2012 Assessment reporting region | Bureau of Meterology 2013, 'Example of the Bureau's climate variability and change trend analysis', www.bom.gov.au/cgi-bin/climate/change/trendmaps.cgi?map=rain&area=aus&season=1202&period=1970<br>Kundzewicz, ZW, Robson, AJ 2004, 'Change detection in hydrological records — a review of the methodology', *Hydrological Sciences Journal/Journal des Sciences Hydrologiques*, vol. 49, no. 1, pp. 7-19 |

Example figures



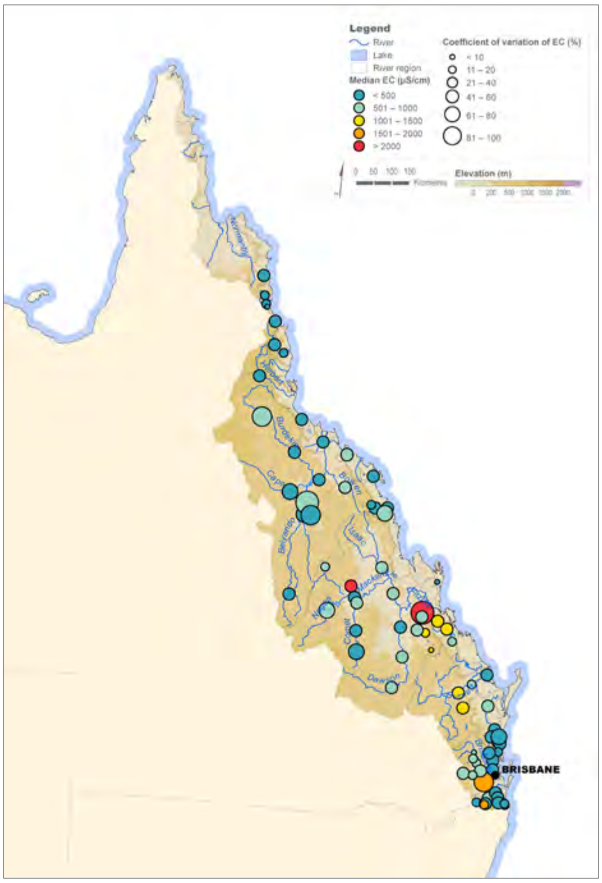
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based seasonal streamflow anomaly analyses**<br>Regional water resources assessments and surface water and groundwater, s. 5 of some regional chapters | **Description**<br>Measured streamflow discharge (ML/day).<br>Data collated for currently operational selected streamflow gauges with records available for at least the past 32 years (July 1980–June 2012).<br>**Source**<br>Bureau | **Description**<br>Annual discharge and decile ranking of annual discharge for the reporting year (July 2011–June 2012) compared to long-term (July 1980–June 2012) annual time series.<br>Decile ranking of summer discharge for the reporting year (November 2011– April 2012) compared to long-term (November 1980– April 2012) seasonal time series.<br>**Resolution of output**<br>Temporal: annual / summer season (November–April)<br>Spatial: sites within relevant 2012 Assessment reporting region | Marsh, T, Sanderson, F 2009, *UK Hydrological Review 2008*, NERC/ Centre for Ecology and Hydrology, United Kingdom, www.ceh.ac.uk/ data/nrfa/nhmp/annual_review/pdf/ Hydrological_Review_2008.pdf |

Example figures



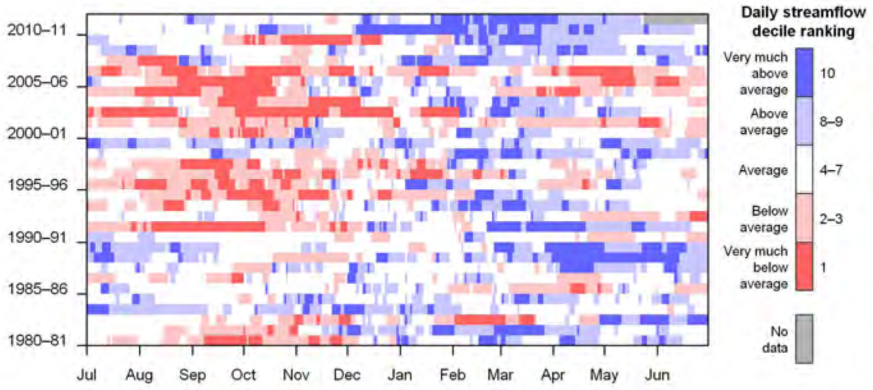
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based annual median with variation of streamflow salinity analyses.**<br>Surface water and groundwater, s. 5 of some regional chapters | **Description**<br>Measured electrical conductivity of streamflow (µS/cm at 25 °C).<br>Data collated for currently operational selected streamflow salinity gauges with records available for at least the past five years (July 2007 –June 2012).<br>**Source**<br>Bureau | **Description**<br>Median of annual streamflow salinity for the reporting year (July 2011–June 2012) are coloured-coded relative to the classification of electrical conductivity (EC) i.e., < 500, 501–1000, 1001–1500, 1501–2000 and > 2000.<br>Coefficients of variation (standard deviation divided by the mean) of annual streamflow EC for the reporting year are different sizes relative to the CV of EC ranges i.e., < 10, 11–20, 21–40, 41–60, 61–80 and 81–100.<br>**Resolution of output**<br>Temporal: annual<br>Spatial: sites within relevant 2012 Assessment reporting region. | Standard analysis and presentation of hydrological information |

Example figures



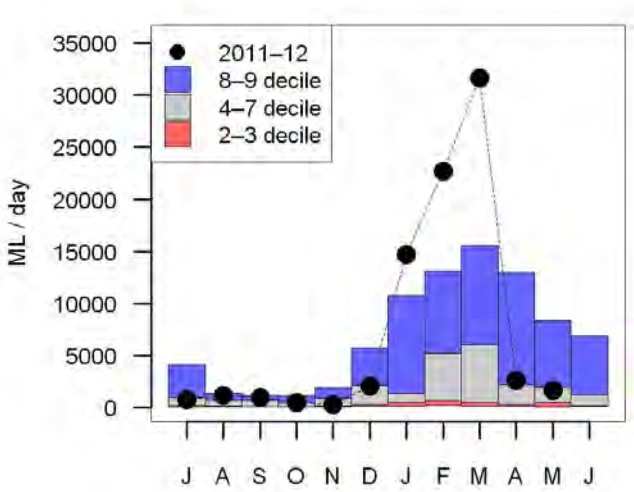
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Decile rankings of daily streamflow**<br>Inflows to wetlands, s. 5 of some regional chapters | **Description**<br>Daily streamflow since 1980<br>**Source**<br>Bureau | **Description**<br>Data ranked in their respective decile categories and given in colours of occurrence<br>**Resolution of output**<br>Temporal: daily | Koehler, R 2004, *Raster Based Analysis and Visualization of Hydrologic Time Series*, Ph.D. dissertation, University of Arizona, USA, p. 189<br>Strandhagen, E, Marcus, WA, Meacham, JE 2006. 'Views of the rivers: representing streamflow of the greater Yellowstone ecosystem', *Cartographic Perspectives*, no. 55, Fall 2006 |

Example figures



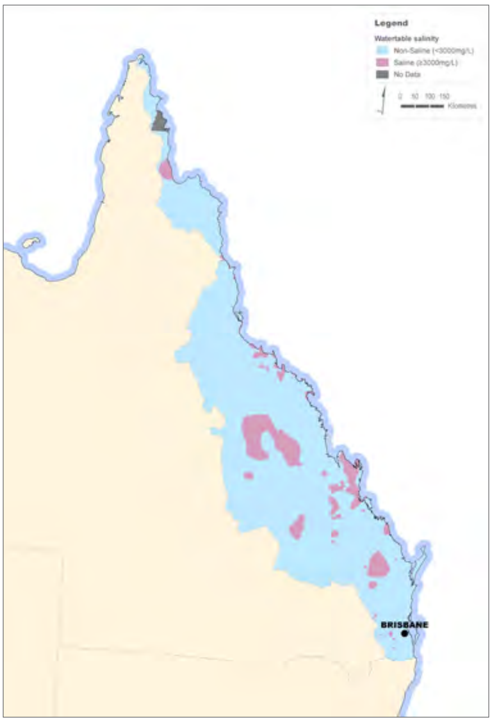
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based time series of monthly flows into wetlands and into selected storages (urban / irrigation)**<br>Surface water and groundwater, s. 5 of some regional chapters<br>Water for cities and towns, s. 6 of some regional chapters<br>Water for agriculture, s. 7 of some regional chapters | **Description**<br>Measured streamflow discharge (ML/day).<br>Data collated for currently operational selected streamflow gauges with records available for at least the past 32 years (July 1980–June 2012).<br>**Source**<br>Bureau | **Description**<br>Graphical presentation of measured monthly streamflow for 2011–12 plotted against derived monthly percentile classes (10–30, 30–70 and 70–90). Percentiles calculated from 32-year (July 1980– June 2012) record.<br>**Resolution of output**<br>Temporal: monthly<br>Spatial: sites within relevant 2012 Assessment reporting region | Standard graphical presentation of hydrological information |

Example figures



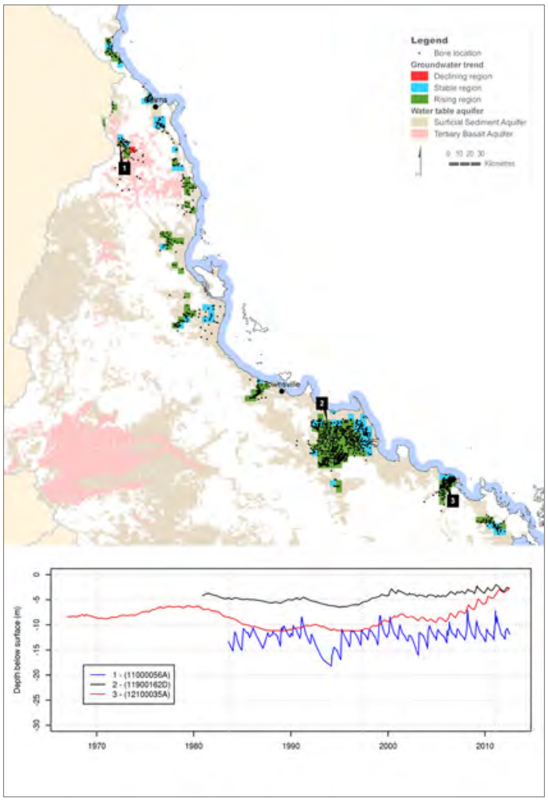
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Regional map of groundwater salinity class**<br>Regional water resources assessments and surface water and groundwater, s. 5 of all regional chapters | **Description**<br>Salinity class of water table aquifer based on electrical conductivity of ground water.<br>Data collated for bores less than 40 m deep for the past 22 years (July 1990–June 2012).<br>**Source**<br>Bureau (Groundwater database) | **Description**<br>Interpolated salinity map using Inverse Distance Weighting, calculated from average electrical conductivity measurements in bores over the 22-year period (July 1990–June 2012) presented in classes of less than 3000 mg/L (fresh) and more than 3000 mg/L (saline). The bores were all less than 40 m deep.<br>Empirical equation (below) used to convert units of Electrical Conductivity (EC) (μS/cm) to Total Dissolved Solids (TDS) (mg/L).<br>TDS (mg/L) =<br>EC(μS/cm at 25 °C) x 0.6<br>**Resolution of output**<br>Temporal: long -term average (22 years)<br>Spatial: sites within relevant 2012 Assessment reporting region | Peer reviewed by senior hydrogeologist from Queensland Government Department of Natural Resources and Mines<br>Department of Primary Industry 2011, *Victoria's groundwater resource*, Victorian Resources Online |

## Example figures



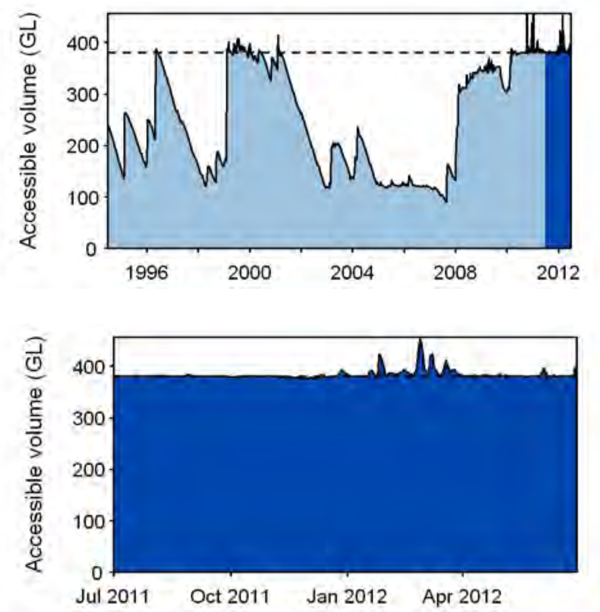
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Regional map and site-based time-series of groundwater level status**<br><br>Regional water resources assessments / Surface water and groundwater (s. 3.5) | **Description**<br><br>Trends in groundwater levels for major aquifers for the past five years (2007–2012).<br><br>Selected bore hydrographs reporting groundwater levels fluctuations for the entire period of records<br><br>**Source**<br><br>Bureau (Groundwater database) | **Description**<br><br>Linear trend (negative, stable, positive) in groundwater is calculated based on a 0.1 m/yr change as the criteria. The period of calculation is the last 5 years. This is represented at a 5- or 20-km grid resolution as: decreasing, stable, increasing, and variable based on a 60% majority of the bores in each grid square (at minimum data from three bores).<br><br>Graphical presentation of variations and changes in groundwater level for selected bores over the 22-year period (July 1990–June 2012)<br><br>**Resolution of output**<br><br>Temporal: 5-year trend (2007–2012) for the maps and length of records for hydrographs)<br><br>Spatial: sites within relevant 2012 Assessment reporting region | Murray–Darling Basin Commission 2004, *Groundwater status: 1990–2000 summary report*, MDB, Commission, Canberra.<br><br>Murray–Darling Basin Commission (2008), *Groundwater status: 2000–2005 technical report*, MDB Commission, Canberra.<br><br>Department of Primary Industry 2011, *Victoria's groundwater resource*, Victorian Resources Online<br><br>Department of Environment and Primary Industries 2013, Ground water levels www.water.vic.gov.au/monitoring/monthly/groundwater_levels#groundwatermaps |

Example figures



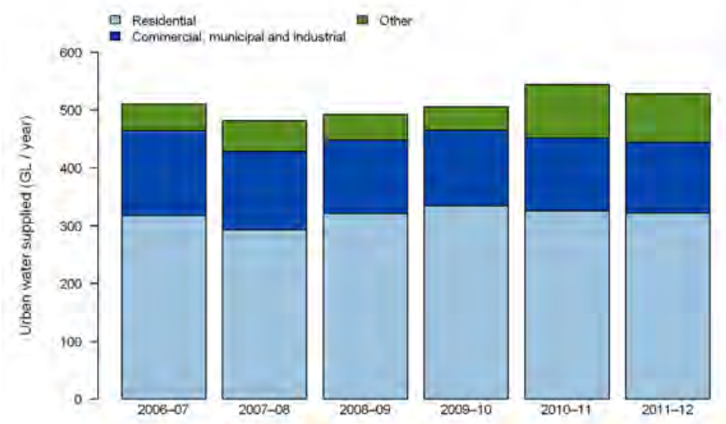
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based time-series of changes in surface water storage (urban / irrigation)**<br>Regional water resources assessments and Water for cities and towns, s. 6 of some regional chapters<br>Regional water resources assessments and Water for agriculture, s. 7 of some regional chapters | **Description**<br>Volume of water held in a major storage.<br>**Source**<br>Bureau's Australian Water Resources Information System (AWRIS) | **Description**<br>Graphical presentation of observed long-term and reporting year storage data (2011–12). Graphical axes represent data as both storage level and per cent full (per cent of maximum capacity).<br>**Resolution of output**<br>Temporal: daily<br>Spatial: sites within relevant 2012 Assessment reporting region | Standard presentation of water storage information<br>water.bom.gov.au/waterstorage/awris<br>www.bom.gov.au/water/about/publications/document/factsheet_waterstorage.pdf |

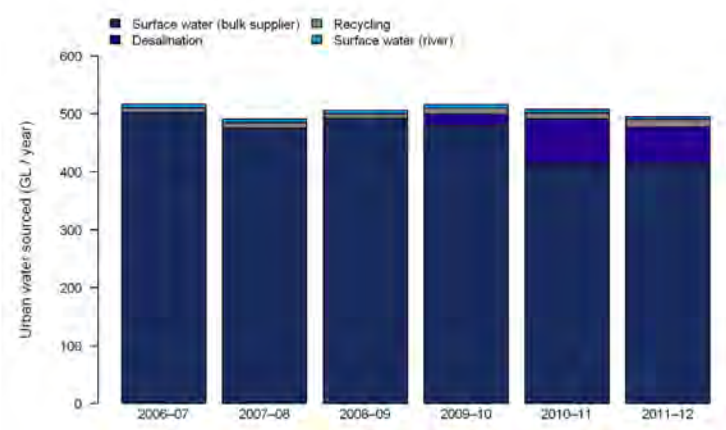
| Example figures |
|---|



| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Time-series of annual urban water supply by source**<br>Water for cities and towns, s. 6 of most regional chapters | **Description**<br>Information about urban water management.<br>**Source**<br>National Performance Report 2009–10: Urban water utilities, archive, archive.nwc.gov.au/library/topic/npr/npr-2009-10-urban | **Description**<br>Plot of total annual water sourced from surface water, groundwater, recycled and desalination water for urban consumption.<br>**Resolution of output**<br>Temporal: annual (July–June)<br>Spatial: urban water supply area within relevant 2012 Assessment reporting region | Standard graphical presentation of hydrological information |

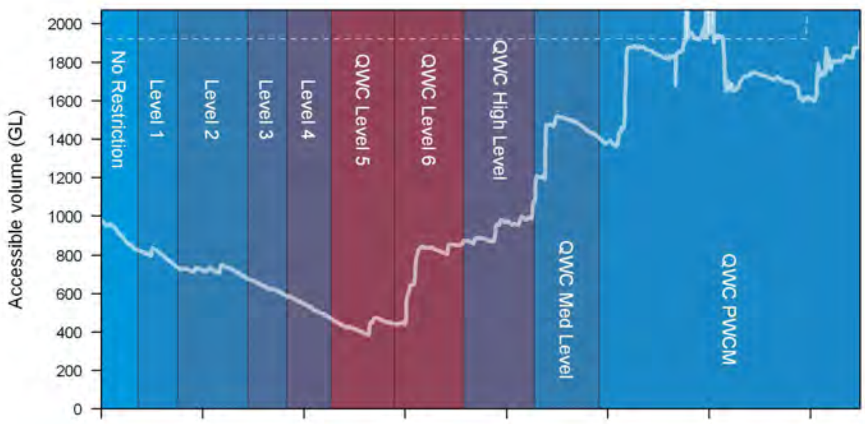
Example figures



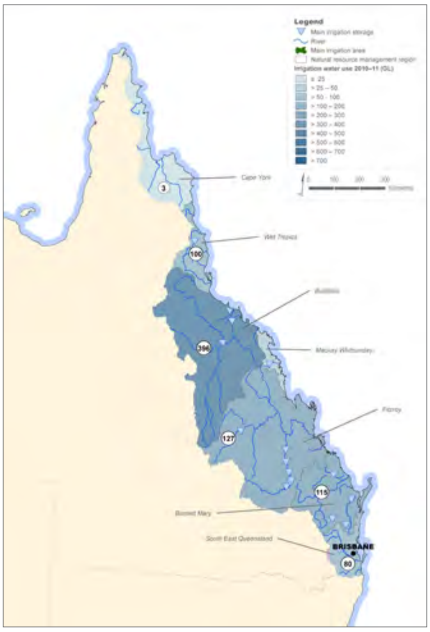
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Changes in urban water restrictions over time**<br>Regional water resources assessments and Water for cities and towns, s. 6 of some regional chapters | **Description**<br>Water use restriction announcements indicating level, commencement and termination dates, a description of water restriction levels and where they apply.<br>**Source**<br>Bureau's water information database | **Description**<br>Graphical representation of water restriction levels over time plotted against a relevant measure of water availability, that is, water storage. Only applied where restrictions may be defined relative to a defined storage level or other resource availability variable.<br>**Resolution of output**<br>Temporal: variable—dependent on announcements of changes to restriction levels<br>Spatial: water supply area within relevant 2012 Assessment reporting region | Standard graphical presentation of hydrological information |

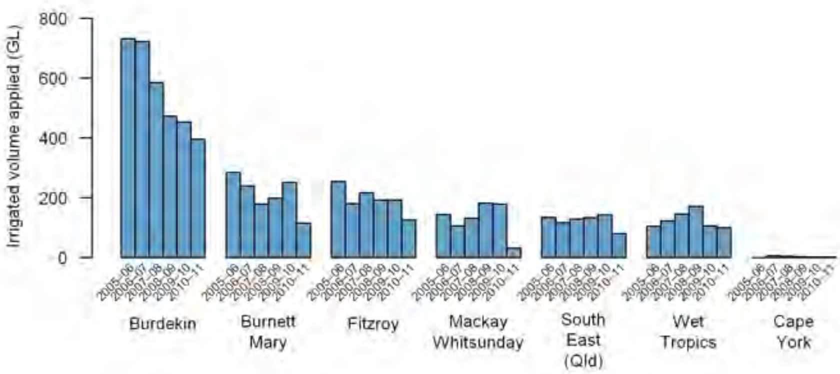
Example figures



| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Patterns in annual irrigation water use**<br>Water for agriculture, s. 7 of some regional chapters | **Description**<br>Annual (July–June) irrigation water use data from ABS *Water Use on Australian Farms* reports. Data are summarised at an NRM level for the four years between 2005–06 and 2010–11.<br>Data for the 2011–12 year were not available at the time of publication.<br>**Source**<br>Australian Bureau of Statistics | **Description**<br>Mapped and graphical representation of annual irrigation water use for each natural resource management region within the reporting region.<br>**Resolution of output**<br>Temporal: annual<br>Spatial: natural resource management regions within relevant 2012 Assessment reporting region | Australian Bureau of Statistics (ABS) 2012, *Water Use on Australian Farms 2010–11*, ABS, Canberra, www.abs.gov.au/ausstats/abs@.nsf/mf/4618.0 |

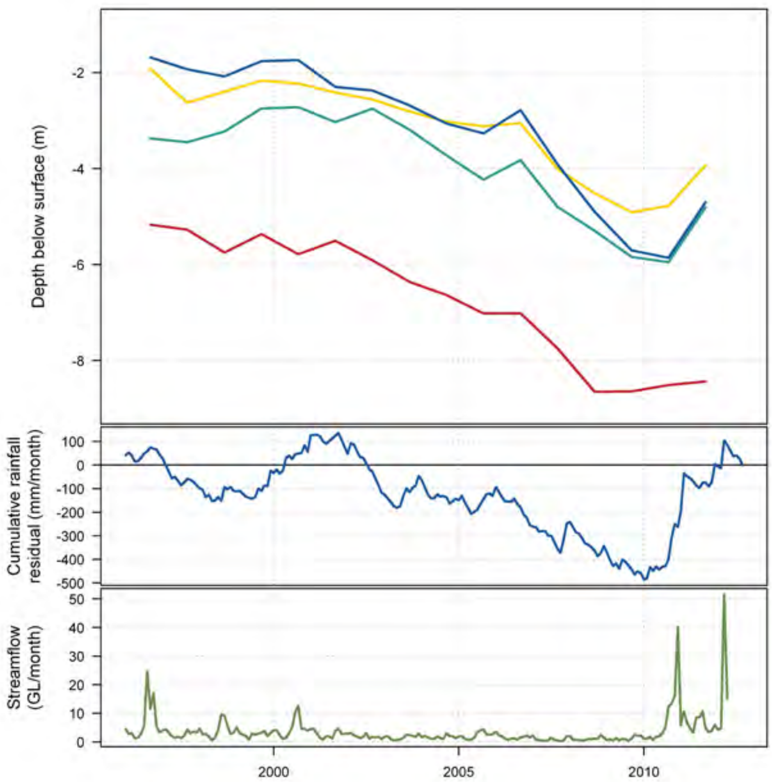
Example figures





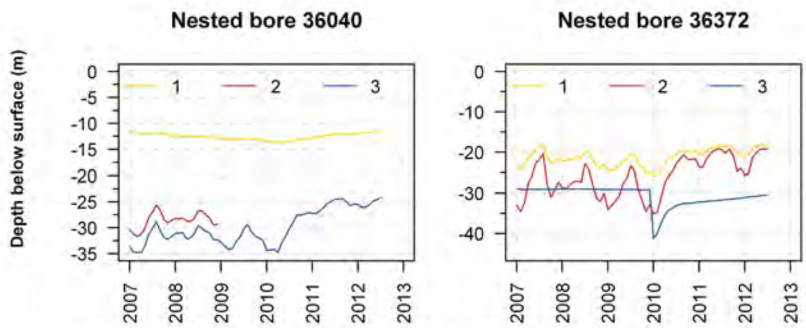
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based time-series of variations in shallow groundwater levels, residual rainfall, streamflow and reservoir level**<br>Regional water resources assessments and Water for agriculture, s. 7 of some regional chapters | **Description**<br>Groundwater level of a bore (relative to datum) and measured streamflow discharge (GL/month) and reservoir monthly level (m).<br>Data collated for currently operational monitoring bores for the past 22 years (July 1990–June 2012).<br>**Source**<br>Bureau's water information database | **Description**<br>Graphical presentation of the relationship between monthly variations in shallow groundwater levels (m), local residual rainfall (mm/month), measured streamflow (GL/month) and monthly reservoir levels (m).<br>The rainfall residual mass curve is based on the following equation.<br>Actual rainfall for month(x) – average rainfall for month(x) + the cumulative sum of (actual rainfall for month – average rainfall for month) for all previous months<br>**Resolution of output**<br>Temporal: monthly<br>Spatial: sites within relevant 2012 Assessment reporting region | Murray–Darling Basin Commission 2008, *Groundwater Status Report 2000–2005*, Technical Report, ed. Murray–Darling Basin Commission, Canberra.<br>Southern Rural Water 2012, *Gippsland Groundwater Atlas*, Southern Rural Water<br>www.srw.com.au/Page/Page.asp?Page_Id=689&h=-1 |

Example figures



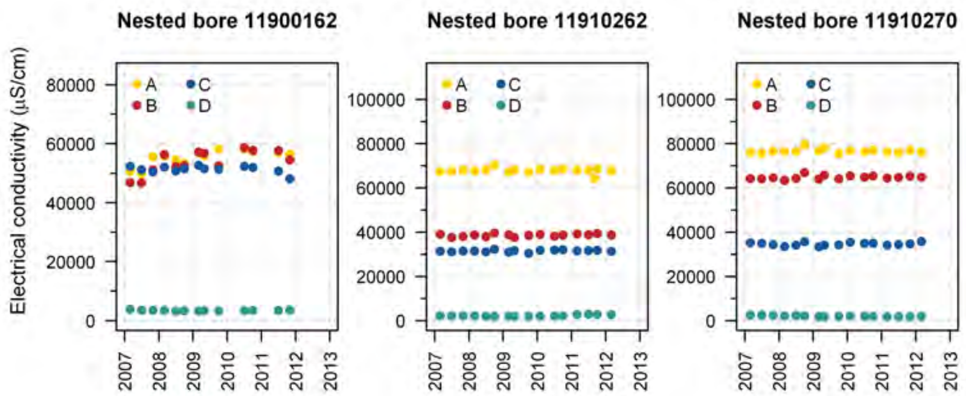
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based time-series of variations in groundwater levels at nested sites**<br>Regional water resources assessments and Water for agriculture, s. 7 of some regional chapters | **Description**<br>Groundwater level of a bore (relative to datum)<br>Data collated for currently operational monitoring bores for the past five years (July 2007–June 2012).<br>**Source**<br>Bureau (Groundwater database) | **Description**<br>Graphical presentation of the relationship between variations in shallow groundwater levels (m) for bores screened in different aquifers at the same location<br>**Resolution of output**<br>Temporal: groundwater—sub-annual depending on the frequency of observation from 2007–12<br>Spatial: selected nested bores | Standard analysis and presentation of groundwater level information |

Example figures



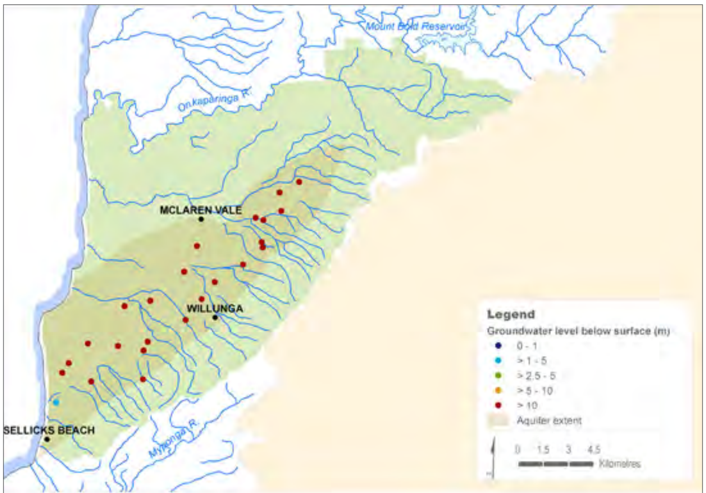
| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based time-series of variations in groundwater salinity at nested sites**<br>Regional water resources assessments and Water for agriculture, s. 7 of some regional chapters | **Description**<br>Groundwater salinity of a bore as electrical conductivity.<br>Data collated for currently operational monitoring bores for the past five years (July 2007–June 2012).<br>**Source**<br>Bureau (Groundwater database) | **Description**<br>Graphical presentation of the relationship between variations in shallow groundwater salinity as electrical conductivity (µS/cm) for bores screened in different aquifers at the same location<br>**Resolution of output**<br>Temporal: groundwater: sub-annual depending on the frequency of observation from 2007–2012<br>Spatial: selected nested bores | Standard analysis and presentation of groundwater salinity information |

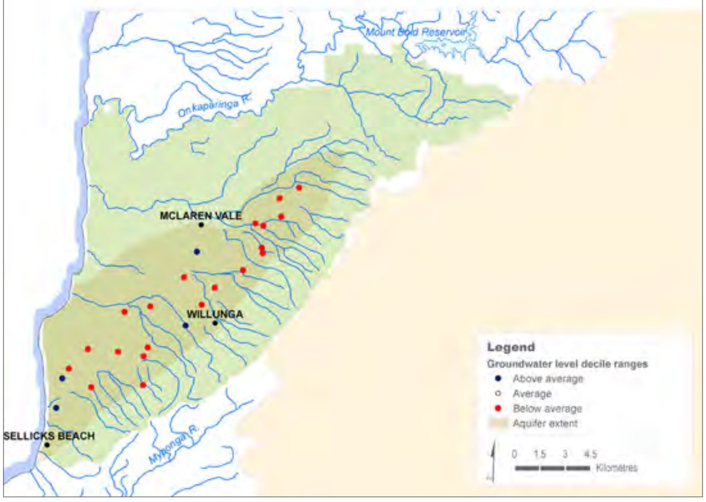
Example figures



| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based analysis of groundwater depth**<br>Regional water resources assessments and Water for agriculture, s. 7 of some of the regional chapters | **Description**<br>Groundwater level of a bore (relative to datum).<br>Data collated for currently operational monitoring bores for the past 20 years (July 1990–June 2012).<br>**Source**<br>Bureau (Groundwater database) | **Description**<br>Standard map presentation of calculated median depth to groundwater (m) for the reporting year (July 2011–June 2012).<br>Decile ranking of median depth to groundwater (m) for the reporting year (July 2011–June 2012) compared to long-term (July 1980–June 2012) levels.<br>**Resolution of output**<br>Temporal: annual (median level and decile rank)<br>Spatial: sites within relevant 2012 Assessment reporting region | Peer review from groundwater expert within the Bureau |

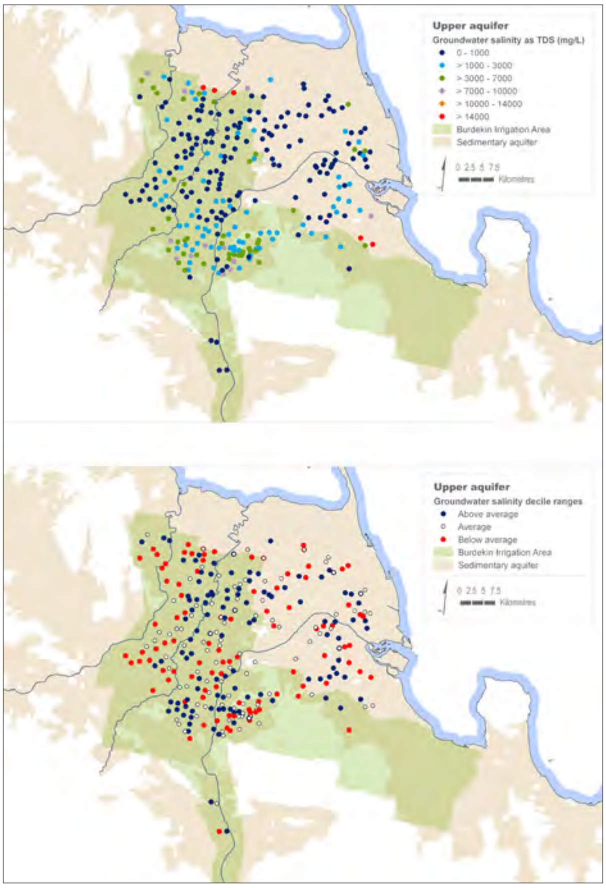
Example figures



| 2012 Assessment analysis | Data | Method | Reference / peer review |
|---|---|---|---|
| **Site-based analysis of groundwater salinity**<br>Regional water resources assessments and Water for agriculture, s. 7 of some regional chapters | **Description**<br>Groundwater salinity of a bore based on electrical conductivity of ground water and reported as total dissolved solids (TDS) (mg/L).<br>Data collated for currently operational monitoring bores for the past 22 years (July 1990–June 2012).<br>**Source**<br>Bureau (Groundwater database) | **Description**<br>Standard map presentation of calculated median groundwater salinity to (mg/L) for the reporting year (July 2011–June 2012).<br>Empirical equation (below) used to convert units of electrical conductivity (EC) (µS/cm) to TDS (mg/L).<br>TDS (mg/L) = EC(µS/cm at 25 °C) x 0.6<br>Decile ranking of median groundwater salinity (m) for the reporting year (July 2011–June 2012) compared to long-term (July 1990–June 2012) levels.<br>**Resolution of output**<br>Temporal: annual (median level and decile rank)<br>Spatial: sites within relevant 2012 Assessment reporting region | Peer review from groundwater expert within the Bureau |

## Example figures



# 5 Data sources and analyses

This section gives background information on data sources, selection procedures and the methods applied to produce the figures in the 2012 Assessment. The data available for download from the website is also discussed.

## 5.1 Data sources and selection procedures

A number of different selection procedures were employed to identify suitable data for the 2012 Assessment. Sources included the Australian Water Resources Information System (AWRIS) (Bureau 2011a), the related web pages and direct contact with data custodians. To the extent that data was available, careful consideration was given to maintain consistency in presenting information across various study regions. The procedures adopted for each data type are discussed below.

### 5.1.1 Estimated flows – high data uncertainty areas

The Australian landscape water balance modelling uses gridded daily rainfall data as a primary model input variable along with a number of gridded meteorological datasets for the calculation of potential and actual evapotranspiration. These are maximum and minimum temperature, humidity and incoming solar radiation.

As the analysis and interpretation of the model results are based on the model runs for a 101-year period (July 1911– June 2012), an understanding of the reliability and quality of model input data is necessary. This is particularly important for rainfall data that exhibit high levels of spatial variability.

Jones et al. (2009) investigated the reliability of the interpolated rainfall surfaces to identify areas of poor quality data following the expansion of the rain-gauge network between 1990 and 2006. They reported interpolation failures are generated as a result of sparse gauge networks that are particularly prominent in the central and western deserts of Australia. Their analysis produced surfaces of rainfall interpolation reliability ranging from 100% unreliable (data show consistent interpolation failure) to zero per cent unreliable, where data are reliable throughout the record as defined by the interpolation technique used in their work.

In the 2012 Assessment, the areas that were more than 20% unreliable (or less than 80% reliable) were identified in the maps of the landscape water balance modelling results. The majority of these areas, which are shown in Figure 6, are located in the central west portions of the continent where the amount of precipitation is minimal and thus they are hydrologically less active compared to the rest of the landscape.

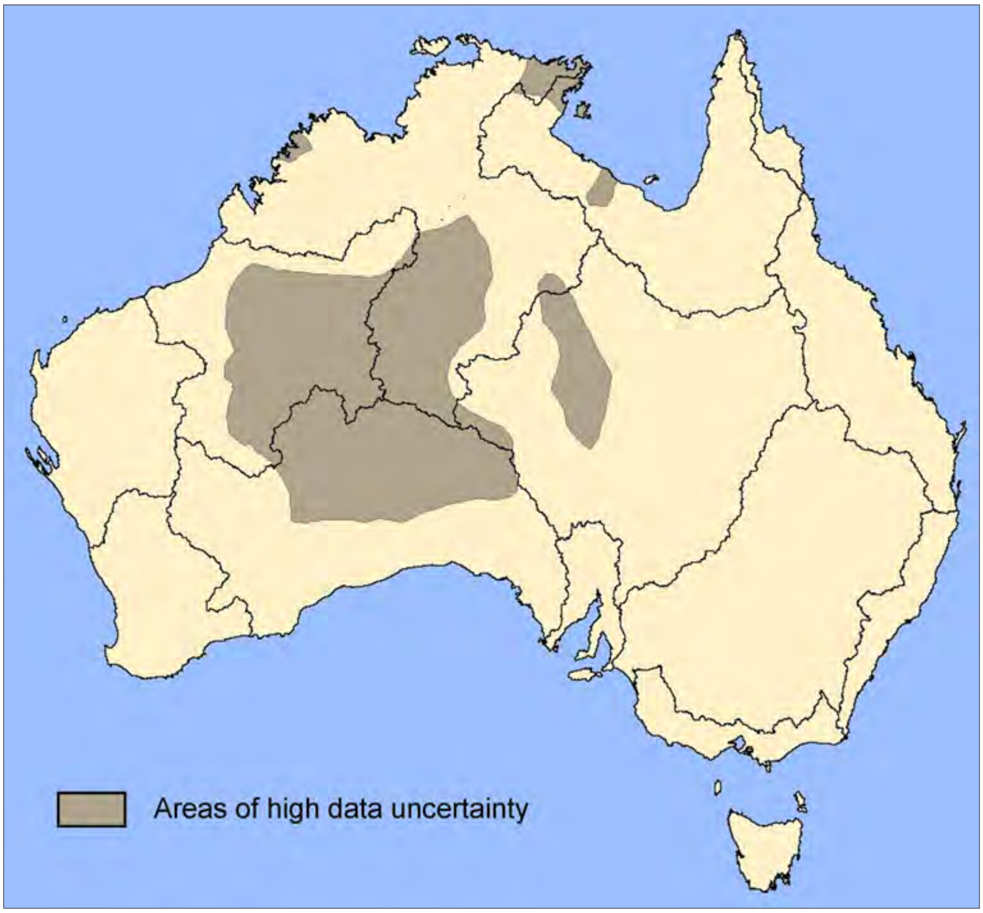



Figure 6 Map of high data uncertain areas which were included in the 2012 Assessment landscape water balance modelling but were highlighted in the maps generated from the modelling results

### 5.1.2 Streamflow and salinity gauge selection

Gauges were selected for all relevant river basins to represent the lower reaches of each basin (that is, to approximate total basin outflow). In the case of larger basins, additional gauges were selected to represent the major 'middle' and 'upper' basin tributaries, to enable a monitoring of the varying status of river flow as water passes from the upper catchment tributaries to the downstream part of the basin. The data for selected gauges are provided in the data files accompanying the report chapters.

Gauges were selected which:

- were in on-going operation in 2011–12 year;
- possessed greater than or equal to 30 years of data record; and
- have data records available within the Bureau's data archives.

Stream salinity gauges were selected in terms of availability and quality of data for river basins, creeks and tributaries to represent the region. A number of factors have been taken into consideration for the site selection of streamflow salinity analysis. These include whether:

- gauges are in ongoing operation and have a history of at least five years to allow statistical analysis;
- sites located where the water in the river is mixed and away from the direct influence of point source pollution such as drains and outlets;
- records are of good quality data (that is, there are limited data gaps and an appropriate measurement frequency); and
- data records are available within the Bureau's data archives.

Summaries of all streamflow and salinity gauges are provided in the data section. The following table provides the standard values of electrical conductivity for different purposes of use (ANZECC and ARMCANZ 200b).

Table 1 Standard value of electrical conductivity (ANZECC/ARMCANZ 2000b)

| Purpose | Typical value of EC (µS/cm) |
|---|---|
| Irrigation water—very low salinity rating * | <650 |
| Irrigation water—low salinity rating* | 650–1,300 |
| Irrigation water—medium salinity rating* | 1,300–2,900 |
| Irrigation water—high salinity rating* | 2,900–5,200 |
| Irrigation water—extremely high salinity rating* | >5,500 |
| Drinking water—cattle | <6,000 |
| Drinking water—sheep | <7,500 |
| Drinking water—human | 800 |

*This is a general guide, as the impact of saline irrigation water on crops varies greatly due to the wide range of crop tolerances to salinity, irrigation method, soil properties and growth stage of the plant.

In selecting gauges for the wetland sections, these needed to be geographically close to the upstream side of the wetland (so as to represent variability in river inflow to the wetland site).

A visual quality check was performed on the run-off hydrographs to exclude unsuitable data from the analysis. These included the outliers and erroneous data and where long gaps existed in the data. It was recognised that some distinct patterns were caused by human actions (for example, construction of new weirs/dams or deviation of river beds) and therefore not all unusual patterns were the result of data errors.

### 5.1.3 Flood classification sites

Sites for the flood classification maps were selected from the Bureau's Australian Integrated Forecast System database. The selection was based on the condition that a quantitative flood forecast classification is present (these sites usually correspond with populated centres and better quality data). It means that for the chosen sites, river water levels are identified, which relate to a minor, moderate or major flood level. The data was quality checked for data errors and inconsistencies. The maps display a flood class for each site, which represents the highest occurring class during the year.

### 5.1.4 Selection of water storages in urban and agricultural context

Water storages were selected based on their representation of the total system storage and system behaviour, and upon suitable data availability for 2011–12.

### 5.1.5 Selection of groundwater bores

The sources of groundwater data used for analyses carried out for this report were obtained from the main government agencies responsible for data collection within the different States. These agencies are the Department of Environment and Resource Management in Queensland, the New South Wales Office of Water and the Department of Water in South Australia. Other States were not considered in this report as, at the time of writing, suitable quality controlled data were not available from the Bureau's data stores.

The relevant aquifers for bores located within the State of New South Wales and within the Murray–Darling Basin were identified based on the Geographical Information System data connected with the Groundwater Status Report 2000–05 (Murray–Darling Basin Commission 2008a). The aquifer information for bores located within the States of Queensland and South Australia were obtained either from the relevant databases or reports.

### 5.1.6 Natural Resource Management regions and irrigation water use

There are 56 natural resource management regions identified for Australia, based on catchments and bioregions. The boundaries were established through agreements between the Commonwealth, State and Territory governments between December 2002 and June 2004 (www.nrm.gov.au/about/nrm/regions/).

The irrigation water use figures available from the Australian Bureau of Statistics and used in this publication are summarised according to natural resource management regions.

These boundaries do not coincide with those of the 2012 Assessment reporting region boundaries. In areas close to the boundaries, population densities are relatively low and the use of these natural resource management regions provides a fair approximation to the 2012 Assessment regions. The areas used are shown in Figure 7 against a backdrop of the situation in the Australian Water Resources Assessments reporting regions. The Wimmera natural resource management region, for example, spans both the South East Coast (Victoria) and Murray–Darling Basin reporting regions. In this publication, the irrigation water use has been reported where majority of the natural resource management region has been inside the reporting regions and no partitioning was attempted in that regard.

## 5.2 Data analysis procedures

### 5.2.1 Guide to landscape flows trend analysis results

Analysis of trends in landscape water flow time-series was performed in order to provide an assessment of potential long-term movement and changes in modelled variables over time. As noted by Radziejewski and Kundzewicz (2004), many statistical trend and change tests are not able to detect a weak trend or a change that is not sufficiently long, but this cannot be interpreted as a demonstration of the absence of change.

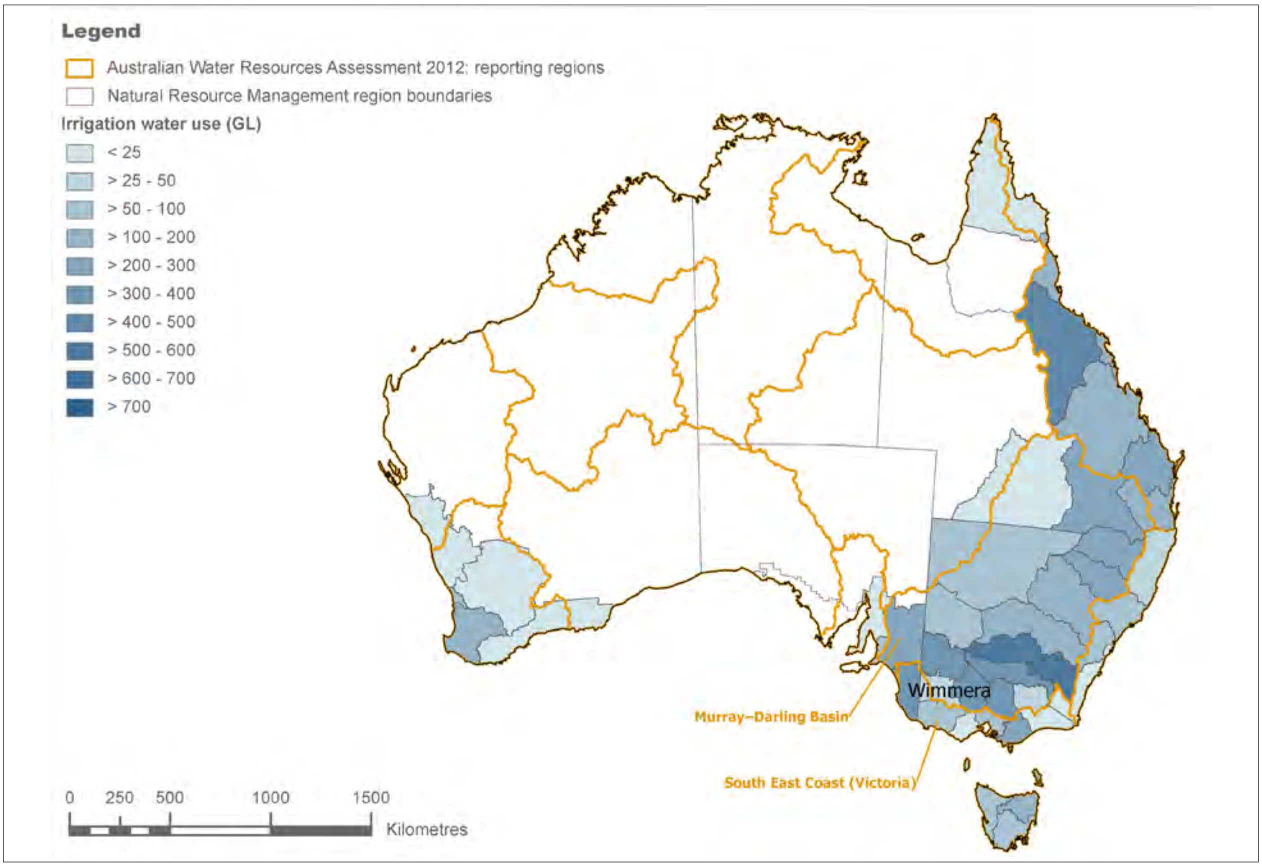



Figure 7 The Australian Water Resources Assessment 2012 reporting region and natural resource management region boundaries

The test statistic for linear regression was used to estimate trends across Australia applying the ordinary least squares estimator to fit a straight line between the points in the time-series. The analysis provides an estimate of whether water flow variables increased or decreased over the defined time period (32 years in the 2012 Assessment) by calculating the gradient of the best-fit regression line.

### Data

The trend analysis was applied to the following national level landscape flows:

- rainfall;
- modelled evapotranspiration; and
- modelled landscape water yield.

These data represent modelled inputs or outputs associated with the landscape water balance model applied for each 5 x 5 km model grid cell, giving full coverage of Australia.

### Linear regression

Linear regression fits a straight line through the set of points in such a way that minimises the sum of square of residuals. The residuals are the differences between the points and the fitted line. The objective of the analysis is to determine the equation of the straight line (given below) that would provide the 'best' fit for the data.

$$Y = B_0 + B_1 X$$

Where $B_0$ is a constant, $B_1$ is the slope (also called the regression coefficient), $X$ is the value of the independent variable (in this case the years), and $Y$ is the value of the dependent variable (annual total landscape water flow variable). The slope coefficient ($B_1$) was calculated at each grid cell for all three flow variables.

### Significance of estimated regression trend

An assessment of the significance of annual trends was also carried out as part of the statistical trend analysis process and the results of the significance tests were included in the regional chapters. The trend analysis was carried out to determine whether these changes are statistically significant. A linear regression t-test was applied to determine whether the slope of the regression line differs significantly from zero. Significance levels of five per cent and ten per cent were chosen for the presentation of results, which are widely used in statistics.

### Length of reference period

To identify the impact of the chosen reference period on the trends and their significance, a comparison has been conducted between the period from 1911–2012 (101 years) and from 1980–2012 (32 years). National maps of the calculated linear regression slopes (in mm/year) and statistical significance are presented for rainfall, evapotranspiration and landscape water yield in figures 8-10.

As can be noted from the figures, a clear difference in the magnitude and significance of the trends for the 101-year and 32-year reference periods exists. Where the magnitudes of the trends are larger for the shorter reference period, the actual significance of these trends is less. In short this means that the reliability of the 32-year trend analysis is less than the 101-year trend analysis; however, there are further assumptions and limitations of the linear regression analysis that need to be taken into consideration.

### Assumptions and limitations

The trends analysis provides only a simplified assessment of (linear) trends in landscape model variables and should, therefore, only be interpreted as providing an indication of the directional tendencies in these variables over the past 32 years. In addition, the significance of these trends should be taken to be indicative as a consequence of the nature of the statistical test and the inherent variability, spatially and temporally, of the underlying data.

Some of the relevant assumptions and limitations of the statistical analysis are identified below.

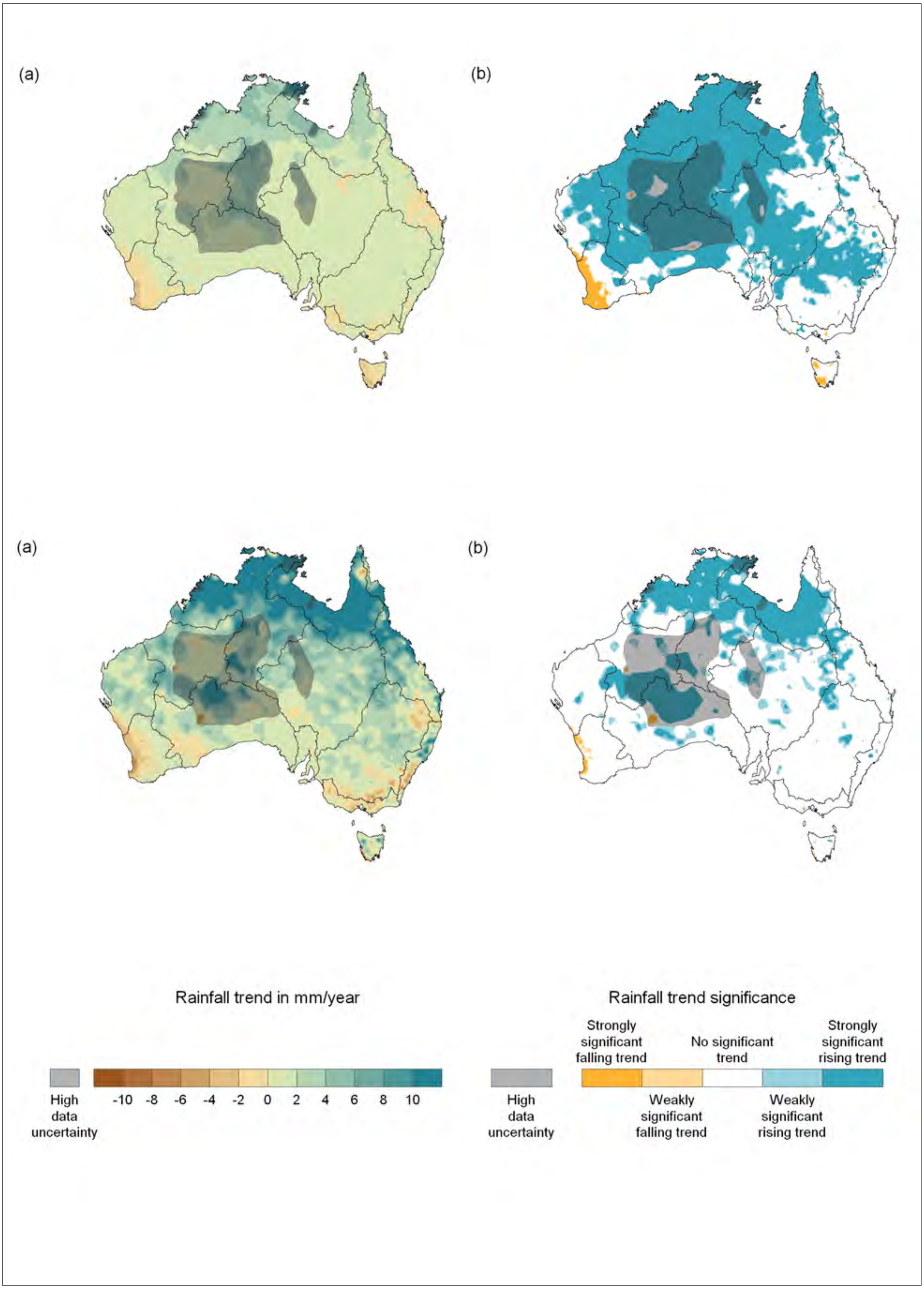



Figure 8 Magnitude and significance of linear regression trends for the period of (a) 1911–2012, and (b) 1980–2012 for rainfall in Australia

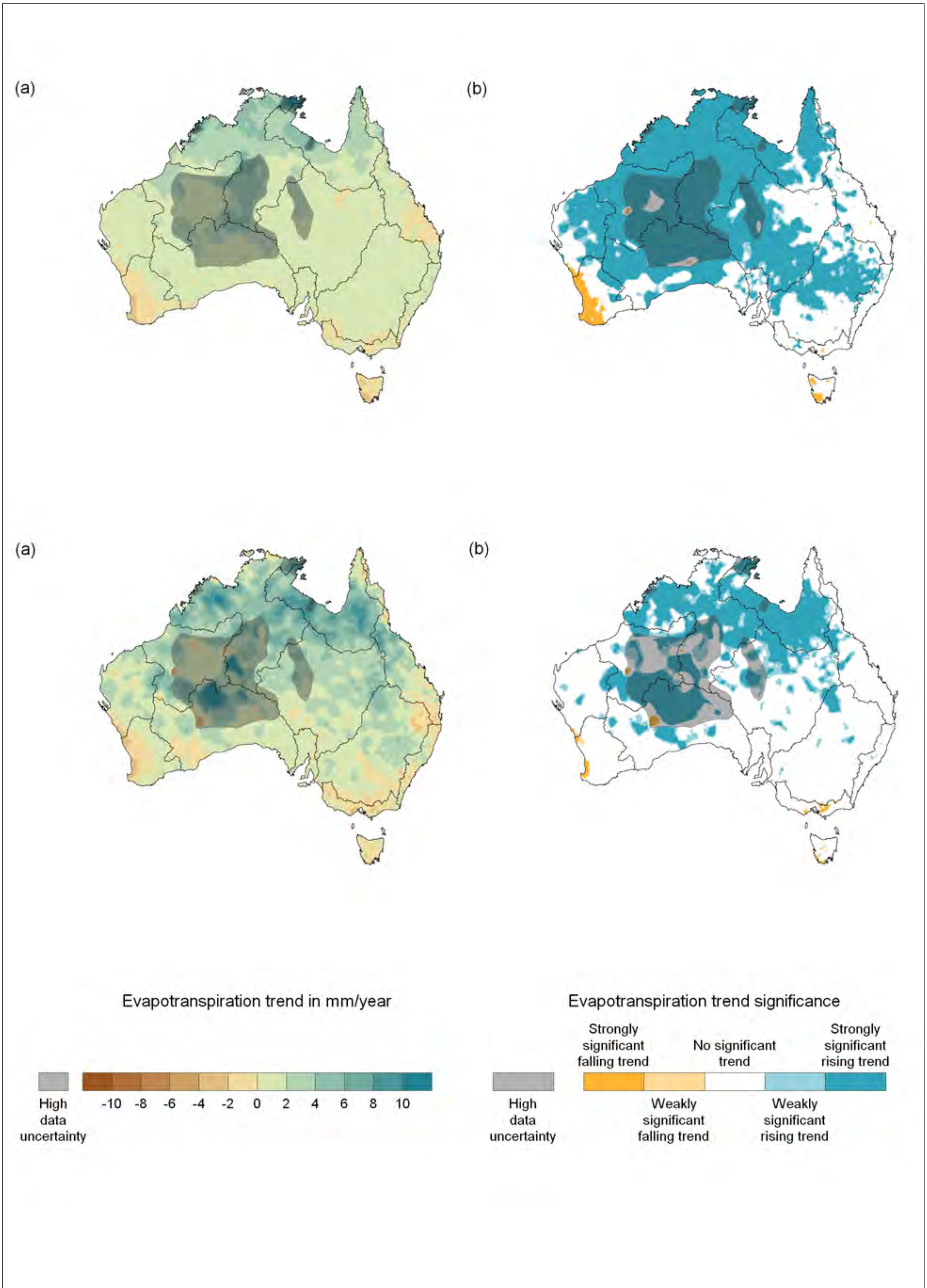



Figure 9 Magnitude and significance of linear regression trends for the period of (a) 1911–2012, and (b) 1980–2012 for evapotranspiration in Australia

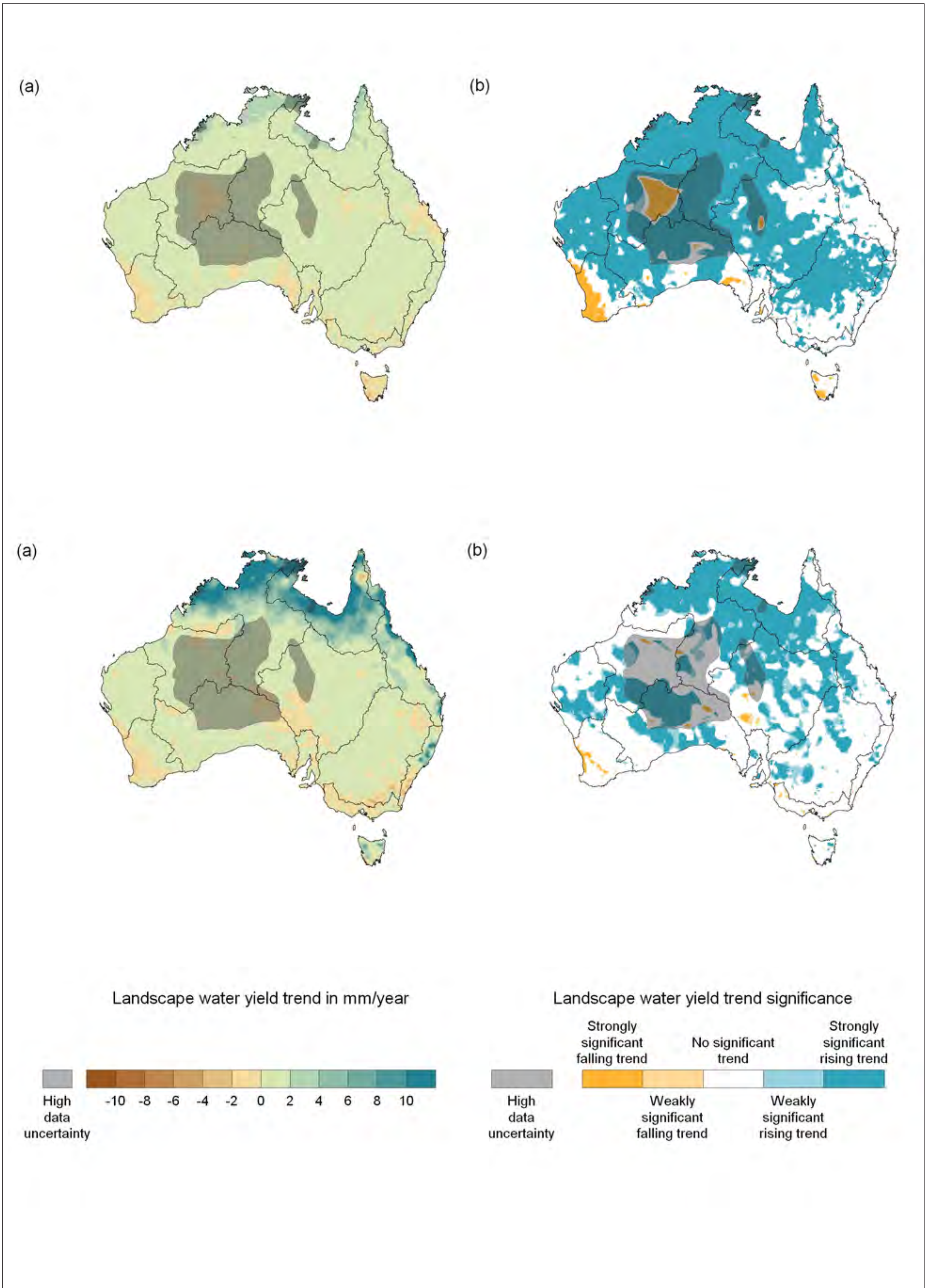



Figure 10 Magnitude and significance of linear regression trends for the period of (a) 1911–2012, and (b) 1980–2012 for landscape water yield in Australia

### Assumptions

- Trends in seasonal and annual rainfall, modelled evapotranspiration and landscape water yield are assumed to be linear over the past 32 years.
- The data points are assumed to be independent with no serial correlation, that is, no short-term correlation between samples.
- The measurement and calculation of the data is assumed to be consistent over space and time, that is, the method used for the generation of landscape water flow surfaces is the same over the 32-year period.
- The data are assumed to be normally distributed. Data transformations to compensate for undesirable data properties, that is, high skewness or strong departure from normality, were not applied.

### Limitations

- Only very limited exploratory data analysis and visual assessment was applied to the data and therefore the depth of understanding of the underlying data is also limited. The large volume of data involved in the analysis and time and resource constraints proved highly prohibitive in the further analysis and understanding of the data and results of statistical analysis. It is acknowledged that without a rigorous exploratory data analysis process, the quality, robustness and reliability of the analysis and its interpretation will be weakened.
- The linear regression test does not identify more complex characteristics of trends. For instance, this approach does not identify break points and step changes in the time-series or changes in trend direction or period trends within the data period.

The 32-year reference period was assumed to be sufficient for the analysis of statistical trends. The analysis of much longer records, that is, up to 101 years, may provide a more statistically robust result, but is mainly diluted by the assumption of homogeneity in the time-series. This is not the case, as over time, the density of the rainfall and temperature stations has changed. Also, the data inputs of solar radiation were only introduced as a measurement for the last 40 years. As a result, the trend assessments in the regional chapters contain the trend map as well as the trend significance map (weak trend = 10% significance, strong trend = 5% significance) to illustrate the magnitude of recent trends (32-years) together with an indicative measure of uncertainty about the statistical significance of the trends.

### 5.2.2 Guide to surface water storage information

This section provides information relating to the water storage figures presented in the 2012 Assessment. This is general information regarding terminology, understanding storage graphs and data, copyright and data supply and general data processing. Storage specific information and data are available within the storage figures' metadata.

#### Water storage terminology

The following terms are used for the water storage volume figures and are visually explained by Figure 11.

- **Per cent of accessible capacity:** the volume of water in storage as a percentage of accessible storage capacity. Note that the percentage full may exceed 100% due to floods.
- **Accessible storage capacity:** the volume of water a storage can hold between the minimum supply level and full supply level, equal to total storage capacity excluding dead storage capacity. This is used to report on the capacity of all storages. The sum of this capacity is used to report on storage systems.
- **Accessible storage volume:** the volume of water stored at a particular time and date. It excludes the dead storage volume and hence is the volume of water that can be accessed under normal circumstances without the installation of additional infrastructure.
- **Dead storage capacity:** the portion of a water storage's capacity that is equal to the volume of water below the level of the lowest outlet (the minimum supply level). This water cannot be accessed under normal operating conditions.

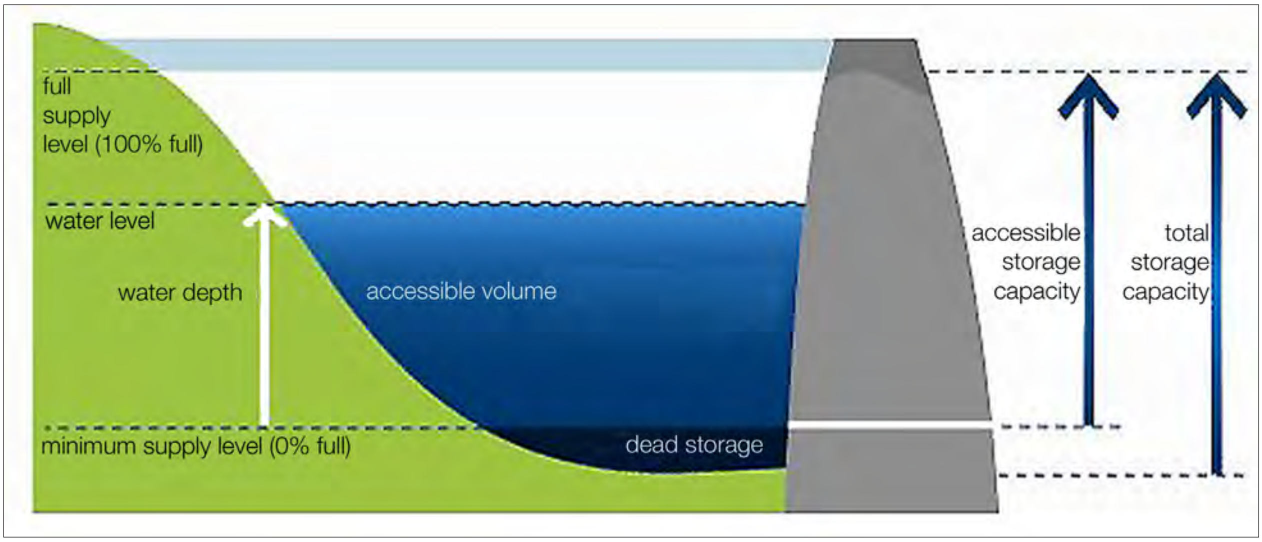



Figure 11 Conceptual representation of a water storage

Storage data graphs in the 2012 Assessment report give an indication of accessible storage, excluding dead storage.

The mean daily accessible storage for a storage or system of storages is shown by a black line, which may contain gaps where data from one or more storages are unavailable. There are no gaps in the blue shading as data were linearly interpolated over the gaps. See, for example, sources of water supply in the South East Coast (NSW) region.

During periods of high river flow or flood, storages can hold more than 100% of their rated capacity.

Percentages are calculated based on the accessible capacity of the storage as of 30 June 2012. Therefore, the storage volume in previous years may also exceed 100% if the storage capacity decreased. Changes in storage capacity can occur for a variety of reasons including sediment accumulation or changes to the height of the dam or outlet structures.

# 6 Data available with the report

## 6.5 Introduction

Data files are available for download for most of the figures contained in the report from the Bureau's website: www.bom.gov.au/water/awra/2012/metadata.shtml

Readily available background information (particularly for the maps) is referenced only, as are a few datasets considered sensitive by the data providers.

Only information shown in the figures is included together with its associated metadata. The original data used to derive this information are described in the metadata. Information is grouped into zip files associated with each chapter. PDF metadata files are associated with the data for each figure. For ease of identification a small JPG file of the figure is also included.

## 6.6 Spatial information

The raster data that are provided with the national overview chapter are not repeated in the regional chapters. A shapefile of regional boundaries is provided to enable selection of regional data subsets. Legend information is provided linking numerical ranges to associated colours used in the report. The raster data are provided in ASCII grid format.

All publicly available background information is available from the Bureau's Geofabric website: www.bom.gov.au/water/geofabric/index.shtml and Geoscience Australia: www.ga.gov.au/products-services/data-applications.html

Spatial information on groundwater unit boundaries is not included but will be available in the near future from the Bureau's website.

## 6.7 Graphed information

The graphed information in the figures is provided in zip files associated with each of the individual chapters. Information is provided in csv format.

# 7 Appendix

The data sources used in developing the 2012 Assessment maps are listed in the following table.

| Type of map | Data source |
|---|---|
| Overview | **Rivers, catchments:**<br>Bureau of Meteorology<br>www.bom.gov.au/water/geofabric/index.shtml<br>Surface network, hydrology reporting catchments<br>**Cities and towns:**<br>Geoscience Australia<br>www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=68695<br>Habitation: built-up areas, place names, populated places<br>**Roads:**<br>Geoscience Australia<br>www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=68695*<br>Transport: Roads<br>**Land use:**<br>Department of Agriculture Fisheries and Forestry<br>http://adl.brs.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml<br><br>*(*reclassified for forestry and nature conservation)* |
| Physiographic provinces | CSIRO<br>www.asris.csiro.au/themes/PhysioRegions.html |
| Elevation | Geoscience Australia<br>www.ga.gov.au/topographic-mapping/digital-elevation-data.html |
| Slope | Derived from Geoscience Australia<br>www.ga.gov.au/topographic-mapping/digital-elevation-data.html |
| Soil types** | CSIRO<br>www.asris.csiro.au/index_ie.html<br><br>*(**map and soil type pie chart)* |
| Land use*** | Department of Agriculture Fisheries and Forestry<br>http://adl.brs.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml<br><br>(***map and land use type pie chart) |
| Population density | Australian Bureau of Statistics<br>www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3218.02011?OpenDocument |
| Rainfall zone | Bureau of Meteorology<br>www.bom.gov.au/climate/environ/other/seas_all.shtml |
| Rainfall deficit | Rainfall deficit calculated in the GIS ArcMap. Long-term average rainfall minus potential evapotranspiration (1961–1999)<br>**Rainfall**<br>www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp<br>**Arial evapotranspiration:**<br>www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp?maptype=3&period=an#maps |
| Rivers and catchments | Bureau of Meteorology<br>www.bom.gov.au/water/geofabric/index.shtml<br>Surface network, hydrology reporting catchments |

| Type of map | Data source |
| --- | --- |
| Annual and summer streamflow | See list of data providers at www.bom.gov.au/water/awra/2012/copyright.shtml and also:<br>**State of Victoria**<br>www.vicwaterdata.net/vicwaterdata/data_warehouse_content.aspx?option=4<br>**State of Tasmania**<br>wrt.tas.gov.au/wist/ui |
| Electrical conductivity | See list of data providers at:<br>www.bom.gov.au/water/awra/2012/copyright.shtml<br>and also:<br>**State of Victoria**<br>www.vicwaterdata.net/vicwaterdata/data_warehouse_content.aspx?option=4 |
| Flood | Unpublished data produced by the Bureau as described at:<br>www.bom.gov.au/water/floods/index.shtml |
| Storage systems | **Bureau of Meteorology**<br>www.bom.gov.au/water/geofabric/documentation.shtml<br>**Surface cartography**<br>See list of data providers at:<br>www.bom.gov.au/water/awra/2012/copyright.shtml<br>and also:<br>**State of Tasmania**<br>www.hydro.com.au<br>**State of South Australia**<br>www.environment.sa.gov.au |
| Wetlands | **Department of Sustainability, Environment, Water, Population and Communities**<br>www.environment.gov.au/water/topics/wetlands/database/index.html |
| Watertable aquifers | **Bureau of Meteorology**<br>www.bom.gov.au/water/geofabric/index.shtml<br>Groundwater cartography |
| Salinity | **Bureau of Meteorology**<br>www.bom.gov.au/water/geofabric/index.shtml<br>Groundwater cartography |
| Groundwater management units | **Bureau of Meteorology**<br>National Groundwater Information System, Groundwater Management Units V2 (unpublished data) |
| Trends of bore locations | Data as provided to the Bureau through the water regulations<br>**State of New South Wales**<br>New South Wales Office of Water:<br>www.water.nsw.gov.au/<br>**State of South Australia**<br>Department of Water:<br>www.waterconnect.sa.gov.au/Pages/Home.aspx<br>**State of Victoria**<br>Department of Sustainability and Environment: Groundwater Management System<br>www.vvg.org.au/cb_pages/gms.php<br>**State of Queensland**<br>Department of Natural Resources and Mines<br>www.nrm.qld.gov.au/water |
| Population range | Australian Bureau of Statistics:<br>www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3218.02011?OpenDocument |

| Type of map | Data source |
| --- | --- |
| Urban supply storage | See list of data providers at:<br>www.bom.gov.au/water/awra/2012/copyright.shtml<br>as well as:<br>**State of Tasmania**<br>www.hydro.com.au<br>**State of South Australia**<br>Urban storage<br>www.environment.sa.gov.au<br>**Geoscience Australia**<br>www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=68695<br>Utility: Pipelines |
| www | **Brisbane water supply schematic**<br>www.seqwgm.qld.gov.au/seq-water-grid-operations/about-the-water-grid/connected-assets<br>as well as:<br>www.previous.seqwater.com.au/public/news-publications/annual-reports<br>**Sydney water supply schematic:**<br>www.sydneywater.com.au/SW/water-the-environment/how-we-manage-sydney-s-water/water-network/index.htm<br>**Canberra water supply schematic**<br>www.actew.com.au/Water and Sewerage Systems/ACT Water Supply System/ACT Water Supply Map.aspx<br>**Adelaide water supply schematic**<br>www.sawater.com.au/NR/rdonlyres/D929607D-8E12-45F2-9AC9-67698E7446EF/0/ar03comp.pdf%5d<br>**Melbourne water supply schematic**<br>www.melbournewater.com.au<br>www.westernwater.com.au/aboutus/Pages/AboutUs.aspx<br>www.sewl.com.au/Pages/Home.aspx<br>www.yvw.com.au/home<br>www.citywestwater.com.au<br>**Perth water supply schematic**<br>www.water.gov.au/RegionalWaterResourcesAssessments/SpecificGeographicRegion/TabbedReports.aspx?PID=WA_SW_614x |
| Irrigation areas**** | **Department of Agriculture, Fisheries and Forestry:**<br>adl.brs.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml<br><br>*(****Reclassified for irrigation areas)* |
| Average annual water use | **Australian Bureau of Statistics**<br>www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4618.02010-11?OpenDocument |

| Type of map | Data source |
| --- | --- |
| Irrigation areas with trends in groundwater bores | Data as provided to the Bureau through the regulations<br>**State New of South Wales**<br>New South Wales Office of Water<br>www.water.nsw.gov.au<br>Coleambally irrigation district CICL pdf report C<br>new.colyirr.com.au/?TabId=69<br>**State of South Australia**<br>Department of Water<br>www.waterconnect.sa.gov.au/Pages/Home.aspx<br>**State of Victoria**<br>Department of Sustainability and Environment: Groundwater Management System<br>www.vvg.org.au/cb_pages/gms.php<br>**State of Queensland**<br>Department of Natural Resources and Mines<br>www.nrm.qld.gov.au/water |

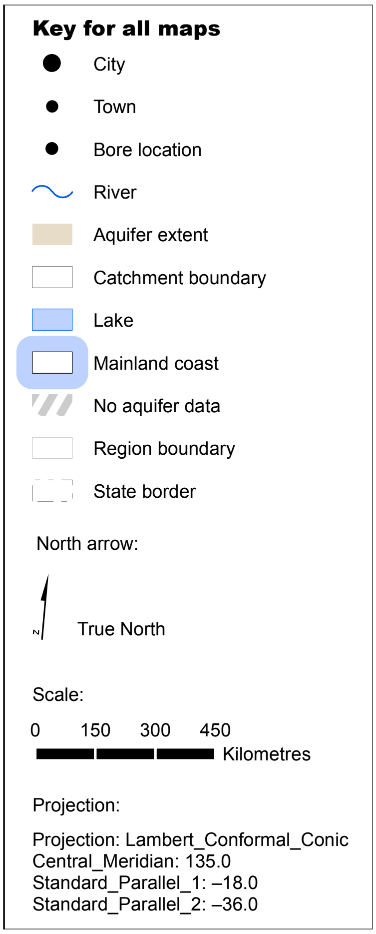



Figure 12 Key for all maps