



Australian Government
Bureau of Meteorology

Improving Water Information Programme Progress Report

ADVANCES IN WATER INFORMATION MADE
BY THE BUREAU OF METEOROLOGY IN 2015



Improving Water Information Programme Progress Report:
Advances in water information made by the Bureau of Meteorology in 2015

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Cover photograph: Wyangala Dam, Lachlan Valley, NSW

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FOREWORD



Several years of below-average rainfall and a strong El Niño led to drought across considerable areas of most States and Territories in 2015.

As supplies diminish and competition for water resources intensifies, we are more aware than ever of the need for trusted and independent information about our water situation.

However, it's not just in times of scarcity that we need reliable water information.

Australia has highly variable rainfall from year to year, affecting streamflow and groundwater replenishment, and water for human use and ecosystem health.

Added to these environmental factors, we see pressures associated with population growth and increased urbanisation.

Our communities, environment, industry and economy depend on reliable supplies of suitable quality water.

Through the Improving Water Information Programme, the Bureau of Meteorology delivers a range of critical information products and services to the water industry and other industries dependent on water.

The product suite covers historical information and trends, current status, forecasts and planning tools.

This information is used for infrastructure design, flood mitigation, water supply forecasting, river management and environmental flows, water sharing plans, policy advice, investment and rural financing.

In 2015 we expanded our water forecasting, modelling, status reporting and interpretation offerings.

We publicly launched a 7-day streamflow forecast service, unveiled an interactive website modelling the various components of the water balance in our landscape, and released a groundwater information product suite for non-technical users.

A new national overview report, *Water in Australia*, describes water availability and use in the context of longer-term trends and climate influences, and an interactive website provides maps and graphs for greater detail and more local information.

Now in the programme's ninth year, we are focused on ensuring our information, products and services are used by those managing and relying on our vital water resources.

A real success story has been the inclusion of our climate and water outlooks in ABC Television's *Landline*, relaying this information to a key rural audience each month.

We don't do all this alone. The programme relies on contributions from hundreds of data providers, research and project collaborators, and lead water agencies in each jurisdiction. I'd like to thank everyone we work with to deliver the programme and ensure this vital information reaches decision-makers.

I'm pleased to report on the programme's achievements for 2015 and look forward to seeing the products and services used to better manage our precious water resources.

We are now better placed than ever to understand the past, evaluate how we are tracking, and anticipate and plan for the future.

Graham Hawke
Deputy Director
Environment and Research

2015 AT A GLANCE



Insight into Australia's water resources—availability and use, climate influences and long-term trends



3D models for 9 major aquifers around Australia



Detailed water accounts covering more than 75% of Australia's population and 70–80% of water use



Location, production and use details for 350+ recycled and desalinated water sources



Pilot water account for Queensland's critical Burdekin region



Streamflow trends at 222 Hydrologic Reference Stations, biennial data update



Streamflow forecasts for the next 7 days at 103 sites across 50 catchments



Monthly review of streamflow and rainfall at 220+ sites



Forecast streamflow over 3 months for 140 sites (in every State and Territory)



Daily updates of streamflows at more than 3200 monitoring sites



Regional data and mapping of water availability and use, climate influences and trends



Daily reporting of surface water storage volumes in 310 publicly owned lakes, reservoirs and weirs



One-stop shop to explore groundwater resources nationwide



Tracking and reporting of water restrictions across major metropolitan and regional urban centres



Groundwater information for 820 000+ bores, including water-level data for 55 000+ bores



Benchmarking report for 78 urban water utilities



Developing a national water information resource



Hydrological models developed by scientists at Bureau of Meteorology and CSIRO



Interactive maps of soil moisture, runoff, precipitation, evapotranspiration and deep drainage across Australia



One-second digital elevation model aids geospatial modelling in Pilbara region, Western Australia



More than 33 million data and metadata files received from 178 providers, containing more than 4 billion time-series observations



Over 6000 people receive regular updates about the water situation, forecasts and information tools



Every month approximately 500 000 people see our climate and water outlook on ABC Television's *Landline*



Water information accessed 830 720 times via website



Sixteen videos watched more than 185 000 times

Water is a critical resource that must be properly managed—particularly in times of scarcity. It represents a significant portion of Australia's economy, yet at the peak of the Millennium Drought it was nearly impossible to answer some fundamental questions about our water resources at a national level.

We were unable say how much water was available and used, and whether patterns were changing over time. We couldn't tell you if the current situation was historically exceptional or not. Nor could we provide a basic forecast about how conditions might change in the coming days, weeks or months.

The Improving Water Information Programme was established in 2007 to improve visibility of this valuable resource and ensure high-quality nationwide information was available to the public and relevant industries.

The Bureau of Meteorology was appointed to lead the programme, to collect, aggregate and analyse water data from more than 200 organisations around the country. Combining this information with the Bureau's existing expertise in weather and climate modelling and forecasting, water forecasts could also provide insight into the future.

Now in the programme's ninth year, a rich portfolio of products and services deliver essential information and forecasts to water managers, policymakers and water-sensitive industries, helping them make informed decisions to manage and use this precious resource wisely.

In 2015 we delivered many new products and services—the culmination of years of research and development—and updated a number of others. Over the next couple of years our focus is to increase the uptake of these tools and ensure they are widely used by relevant industries.

PROGRESS AGAINST PROGRAMME OBJECTIVES



The programme aims to achieve ten objectives. A summary of performance against each objective is included here, along with where to find information about 2015 achievements throughout this report.

- 1. Establish enduring national water data sharing and licensing arrangements.**
 - Water Data Transfer Format (WDTF) released 2009, with updates in 2010, 2012 and 2013, along with a validation service for suppliers to check if their data is compliant.
 - Contributed to WaterML2.0, an international Open Geospatial Consortium standard for water data exchange.
 - Part 1 (Timeseries)—approved 2012; for hydrological observations data like water level or discharge.
 - Part 2 (Ratings, gaugings and sections)—approved 2015; for information on river ratings, gaugings and cross-sections.
 - Most data is provided under Creative Commons licensing arrangements to better facilitate sharing.
- 2. Develop and disseminate national water information standards.**
 - Water Accounting Conceptual Framework delivered 2009, updated 2014.
 - Water Accounting Standards delivered in 2012 and 2014.
 - Australian Water Information Dictionary developed 2011, updated as required.
 - Ten National Industry Guidelines for hydrometric monitoring delivered in 2013.
 - Water Quality Metadata Guidelines endorsed by Water Monitoring Standardisation Technical Committee in November 2015.
 - National Aquifer Framework delivered in 2013, to standardise geological terminology before data is submitted for the Bureau's groundwater products.



3. Build and maintain the Australian Water Resources Information System to underpin all of the Bureau's water information products and services.

- Data storage and management (page 7)

4. Collate, standardise and archive water data collected by more than 200 organisations named in the schedules to the Water Regulations 2008.

- Water Restrictions (page 10)
- Water Storage (page 10)
- Groundwater Information Suite (page 13)
- Water Data Online (page 10)
- Monthly Water Update (page 11)
- Hydrologic Reference Stations (page 11)

5. Support data providers to improve the coverage, currency and accuracy of water data collected around Australia and enable ready transmission of data to the Bureau.

- The Modernisation and Extension Programme provided \$78 million over five years (2007–08 to 2011–12), funding 463 projects to update monitoring networks and improve data quality and delivery to the Bureau.

6. Provide the Australian public with free, online access to reliable water information.

- Products and services available from www.bom.gov.au/water

7. Analyse and report on trends in water availability and quality across the nation.

- Australian Water Resources Assessments (2010 and 2012)
- *Water in Australia* 2013–14 (page 8)

- Regional Water Information (page 9)
- Australian Landscape Water Balance (page 20)
- Climate Resilient Water Sources (page 14)
- Hydrologic Reference Stations (page 11)
- Water Storage website and iPhone app delivered 2010. Storage levels updated daily for 310 publicly owned lakes and reservoirs—representing more than 95% of water held in public storages.

8. Publicly disclose water entitlements, allocations, trades and take for all major water supply systems in an annual National Water Account.

- National Water Account (page 8)
- *Water in Australia* (page 8)
- Water Markets dashboard (page 15)

9. Provide effective and reliable streamflow forecasting services for high-priority water supply systems.

- Hydrological Forecasting System (page 16)
- Flood forecasting and 7-day streamflow forecasts (page 16)
- Seasonal streamflow forecasts (page 18)

10. Enhance the science and technology base of the Bureau's water information products and services by supporting strategic research and development.

- Water Information Research and Development Alliance (page 22)
- 7-day streamflow forecasts (page 22)
- Seasonal streamflow forecasts (page 22)
- Australian Landscape Water Balance (page 23)

STRONG FOUNDATIONS

Through the programme's early years, we focused on developing consistent definitions, data formats and processes to ensure water information was comparable around the country and easily transferred between data collectors and the Bureau.

Now well-established as a standard, the Water Data Transfer Format is used to deliver more than 80 per cent of all water data to the Bureau, with around 100 organisations providing data in the latest version. This reduces processing time and allows us to share information more quickly with users.

In addition, 90 per cent of all data providers use a Creative Commons licence, which also simplifies sharing and re-use.

IMPROVING OBSERVATIONS

Through the first five years of the programme, just over \$78 million was provided for 463 projects to improve Australia's water monitoring and data reporting networks. This investment continues to deliver benefits long after the money was spent.

STRENGTHENING FOUNDATIONS

While our focus has shifted to product and service delivery as the programme matures, we continue to develop and refine national standards as we learn through user experience and feedback on existing standards.

In 2015 the Water Monitoring Standardisation Technical Committee finalised National Industry Guidelines for hydrometric monitoring and water quality metadata. Application of these guidelines will ensure data collected from one organisation is directly comparable and compatible with data for the same parameter for another organisation. They also provide a common understanding for data suppliers and users about how data are collected and their fitness for purpose.

Simplified data entry for annual reporting

The dispersed and variable nature of the Queensland water industry presented some unique challenges and opportunities for timely delivery of accurate data to the Bureau and other government agencies. Recognising this, between 2008 and 2012 more than \$1 million was invested through the Modernisation and Extension of Hydrologic Monitoring Systems Programme to help develop the Statewide Water Information Management (SWIM) system and automate data transfer processes.

As part of the SWIM project, the Queensland Water Directorate developed SWIMLocal which is a cloud-based data management system. Following a trial period, it is now used by Toowoomba Regional Council and various other Queensland councils and water utilities—in fact, 85 per cent of mainstream councils report using SWIM. The system allows organisations to synchronise water data from dispersed locations and store it in the centralised SWIM database for 'click of a button' reporting to the Bureau and other State and Commonwealth agencies in specified formats.



'SWIMLocal has made daily reporting of water monitoring data simple and efficient. We can import data from two or more sources, including SCADA, to an Excel template and upload through the SWIM portal.'

Wendy Brunckhorst, Coordinator
Water and Waste Reporting, Toowoomba Regional Council

Through our Water Information Research and Development Alliance with CSIRO, we have also been contributing to the development of several standards to facilitate international sharing of water data.

WaterML2.0: Part 2 (Ratings, gaugings and sections) was approved as an implementation standard by the Open Geospatial Consortium in July 2015. The new standard supports the exchange of river ratings, gaugings and cross-section information in several formats.

We contributed to the development of the World Meteorological Organization Integrated Global Observing System Metadata Standard, which was adopted in June 2015. This standard covers a set of core metadata to support recording, processing and transmission of environmental observations to the World Meteorological Organization.

Work continues on an international standard for groundwater data. In 2015, we participated in an interoperability experiment conducted through the Open Geospatial Consortium to test the Groundwater Markup Language version 2 (GroundwaterML2). We also ran a pilot project to demonstrate the ability to exchange National Groundwater Information System data as GroundwaterML2 and feed it into a web service. GroundwaterML2 is expected to be finalised and adopted as an international standard in 2016.

DATA STORAGE AND MANAGEMENT

Since the programme commenced, the Bureau has received over 33 million water data files from 178 providers around Australia. This equates to more than 13 000 new files per day and a total of 3.8 terabytes of data transferred via secure internet gateways, email or disk.

During 2015, we made significant progress towards implementing a new data warehouse to store all that data, and a business intelligence tool for web dashboards and mobile applications to better present information to users.

More than 6 million files have been added to the new data warehouse, which will replace the existing Australian Water Resources Information System. A new data registry has been developed to track all files received, along with a data flow console to monitor files as they progress through the data processing pipeline.

We also re-engineered Water Data Transfer Format validation tools and integrated them into data processing systems to automatically validate incoming data, with improved error handling and validation rule management. This means we can have greater confidence in the quality of the data behind Improving Water Information Programme products and services.

We are using a business intelligence tool to develop an integrated portal for our water storage and water markets information. This will be the first of many streamlined dashboard style web pages to be developed using business intelligence tools.

IMPROVING DATA COLLECTION AND REPORTING

In 2015 we led an inter-agency working group to identify ways to reduce any duplication and unnecessary burden of water reporting and data collection across government agencies. This not only makes the reporting process more efficient, it also reduces the potential for errors—improving the quality and reliability of the available water information for all users.



WATER STANDARDS

'...ensuring that water monitoring and data collection is performed to an accepted standard which provides the client with assurance that the information collected is reliable.'

ASSESSING AND ACCOUNTING FOR WATER RESOURCES



Understanding what has happened in the past can give us a good idea of what might happen in the future under similar circumstances, meaning policymakers and water managers can intervene earlier to secure water resources for critical needs ahead of anticipated water scarcity. It can also help us track the effectiveness of policy reform and steps taken to secure supplies or protect the environment.

While local water managers can tell you about the state of water resources in their area of responsibility, planning at a national level needs national information.

The Bureau collects, standardises, aggregates and analyses information from around 200 providers to deliver a national picture of water resources.

DETAILED WATER ACCOUNTS FOR KEY REGIONS

We published our fifth annual National Water Account in 2015, providing detailed records of 2013–14 water availability and use for nine key regions around the country. Applying the rigour of financial accounting to water resources, this series is building a comprehensive picture of water management in areas where more than 75 per cent of Australia's population lives.

While it is important to have a rigorous and detailed account of our water resources, we also understand that most people are interested in the general situation—that's why we developed a short video in 2015 to give an overview of the account. Not only did this summarise the situation for regular account users, it allowed us to share the information more broadly and engage with the general public via social media.

Queensland's Burdekin River's significance to agriculture, power generation and Great Barrier Reef ecosystems meant it was just a matter of time before it was added to the national account. We delivered a pilot account for the Burdekin region this year, with the first full report to be included with the National Water Account 2015, released in the first half of 2016.

A NATIONAL OVERVIEW

The National Water Account scrutinises water resources and use for key water-use regions, but doesn't cover the entire country. That's where our new *Water in Australia* report comes in.

Water in Australia 2013–14 presents a national overview of water availability and use, climate influences and long-term trends. It draws on a wide range of sources to describe:

- physical water resources—including rainfall, groundwater, streamflow and the drivers of specific water conditions in the reporting year;
- water availability and use—including entitlements, storages, water supply, and human and environmental use.

Water in Australia takes over from the former *Australian Water Resources Assessment* report and *National Water Account Summary*—retaining and building on the strengths of both. It has the detailed use information for major water-use areas from the National Water Account and the national coverage of the *Australian Water Resources Assessment* report.

Water in Australia is intended to be an annual reference document for policymakers, providing background and context for policy development to address Australia's ongoing water challenges.



DELVING INTO THE DETAIL

Our complementary Regional Water Information website uses maps, graphs or tables to present monthly and annual data for climate and water resource conditions, water availability and use, at scales varying from national down to river region. It also contains long-term averages and trends.

Regional Water Information currently contains complete datasets for 2013–14, and 2014–15 datasets are being added as they become available.

This self-help tool was released in late 2015. We will focus on increasing awareness and use throughout 2016.

NEW URBAN WATER REPORTING RESPONSIBILITIES

For the first time in 2015, as an extension to the Improving Water Information Programme, the Bureau delivered the report which benchmarks performance of urban water utilities around Australia.

The *National performance report 2013–14: urban water utilities* covers approximately 150 performance metrics and indicators from 78 water utilities and councils across Australia. The indicators include water resources, finance, pricing, assets, health, environment and customers.



Assistant Director, Water Information Services, Dr Ian Prosser explains how the Bureau's water assessment products can be used by members of the Water Services Association of Australia at a forum in August 2015.

This was the ninth report in the series, previously delivered by the former National Water Commission on behalf of the State water regulators. We have now been contracted to prepare the next two years' reports.

This is a natural fit with the Bureau's other responsibilities in urban water reporting through the National Water Account, Water Storage and Water Restrictions websites.



WATER DATA

'We can plan better by having more reliable data and trends, which allows us to support irrigators more usefully...'

'Efficiencies in accessing rainfall data and efficiencies in the early phases of projects regarding hydrology. The ready spatial data access has locked in a reliable level of quality, leading to good decision-making at the important early phases of a project...'

'They give us data we otherwise wouldn't have.'

WATER STATUS AND AVAILABILITY



With hundreds of organisations involved in managing water around Australia, it has been difficult historically to get a national picture of the water situation at any point in time. The Bureau now offers a series of information products to give greater visibility of the status of surface water, groundwater and alternative water sources around the country.

SURFACE WATER AVAILABILITY

Our Water Storage website and iPhone app were among the first tools delivered through the Improving Water Information Programme in 2010 and remain popular, with almost 300 000 unique visits to the website in 2015.

Providing daily storage levels for 310 publicly owned lakes and reservoirs; this represents more than 95 per cent of all water held in public storages around Australia. We commenced work to upgrade the user experience and visuals for the Water Storage website in 2015 and aim to release a new-look site in the first half of 2016.

To complement water storage information, we also have a portal to report on water restrictions around the country. Water restrictions are a common tool used to manage demand during periods of water scarcity. Some restrictions are set at a State level, while most are set by local water supply agencies, and have trigger levels that vary according to time of year, water storage levels and forecast conditions. Our Water Restrictions portal provides a single point of reporting for all water restrictions around Australia and was accessed more than 21 000 times in 2015 (unique visits).

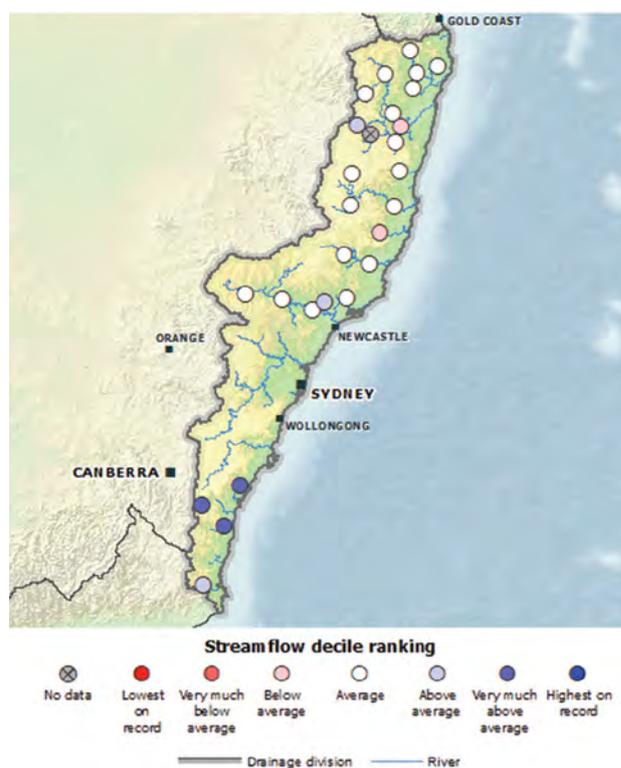
In 2015 we made it easier for data providers to update when changes to restrictions are announced locally, ensuring that restrictions information is accurate and timely for users of the site.

STREAMFLOW STATUS AND TRENDS

Daily data

First released in 2014, Water Data Online was further developed with ratings and gaugings data made available for monitoring stations across Australia, and options added to download data in WaterML2.0 format.

Water Data Online is a single online repository of water level and discharge data for around 3300 monitoring sites around Australia, collected by water agencies around the country and updated daily. Water Data Online provides access to our most extensive streamflow dataset, combining historical and recent monitoring information. It also offers some commonly-used statistical analyses to put the streamflow data into historical context.



Monthly Water Update for Southeast Coast (NSW) drainage division, August 2015.

Monthly summary

Our Monthly Water Update provides a quick overview of rainfall and streamflow for the previous month.

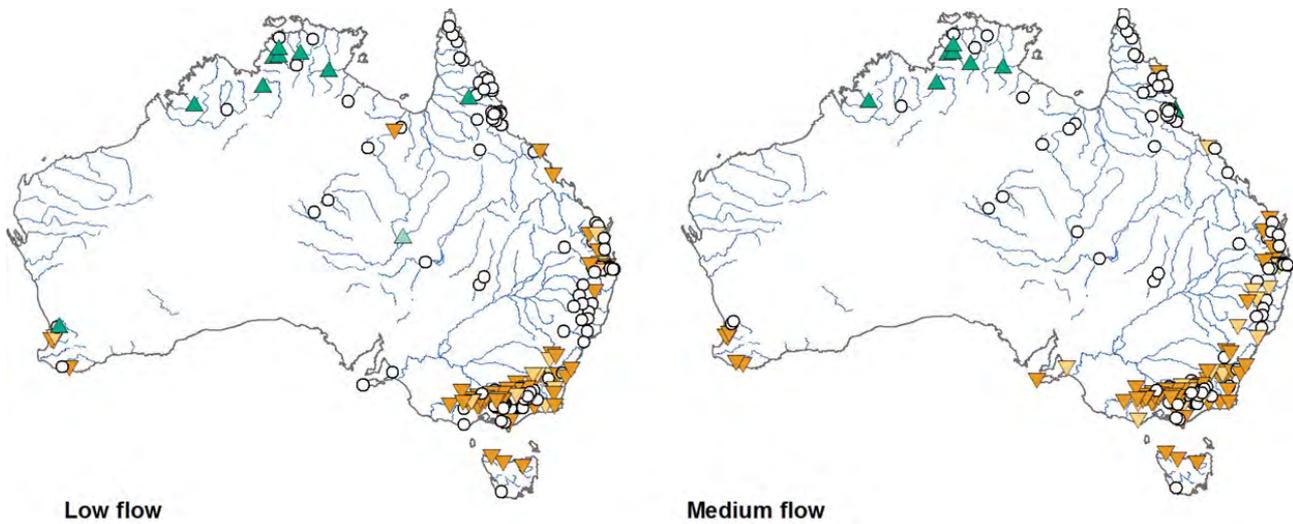
Released for the first time in September 2015, it shows streamflow and rainfall in relation to long-term averages for more than 220 gauging stations across nine of Australia's 13 topographic drainage divisions.

The service monitors gauges in the downstream sections of main rivers to report total river outflow, with additional gauges upstream in larger catchments to show different flows in various parts of the catchment.

Long-term trends

Hydrologic Reference Stations are a network of 222 streamflow monitoring sites meeting strict selection criteria to monitor long-term, natural trends in streamflow. Each site is unaffected by water-related development, such as dams and irrigation diversions, and has at least 30 years of streamflow records. Collectively, these sites cover every hydro-climatic region in Australia.

In 2015 we completed the first biennial data update, adding 2013 and 2014 streamflow data and an additional site, which now exceeds the 30-year requirement.



Streamflow trend and significance

- ▲ Strongly significant rising trend
- ▼ Weakly significant falling trend
- No significant trend
- ▲ Weakly significant rising trend
- ▼ Strongly significant falling trend

Trends since 1975 in low and medium streamflow at Hydrologic Reference Stations.

This dataset was analysed to determine long-term streamflow trends, revealing some distinct patterns around the country. In general, since 1975, flows are decreasing in southern Australia but increasing in the northern tropics. More specifically, moderate to low flows are more likely to show an increasing trend in the north, while moderate to high flows are decreasing in the south.

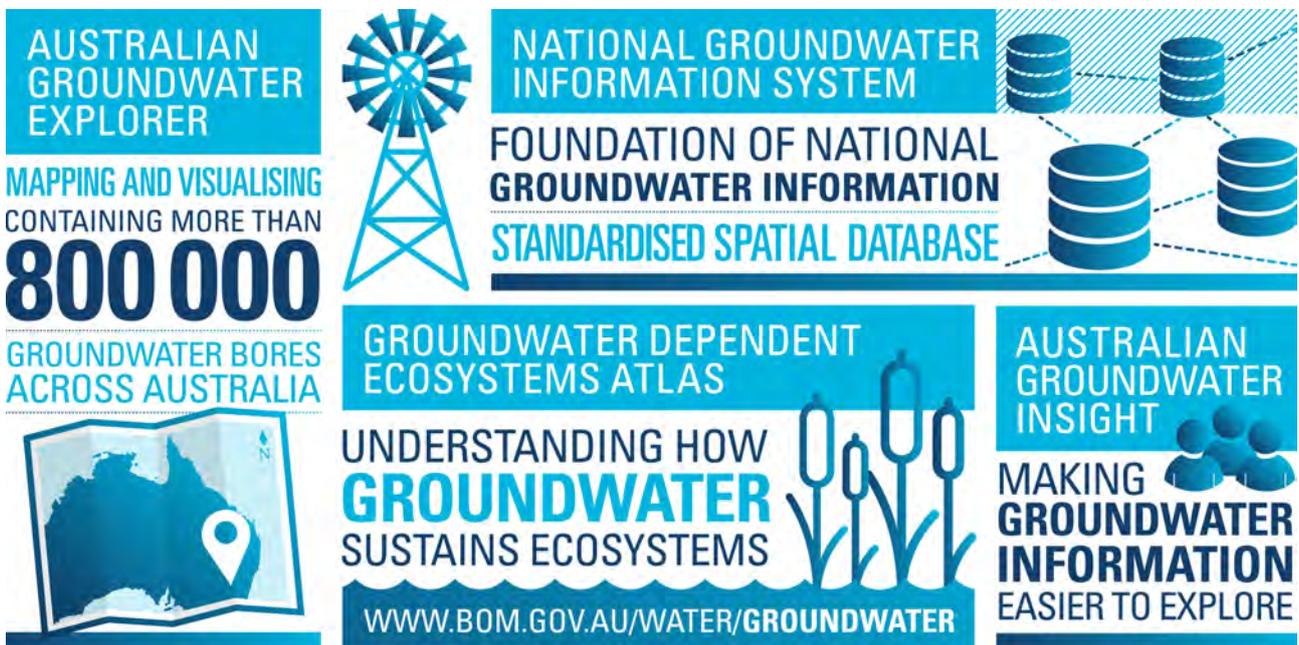
Hydrologic Reference Stations data are also being used by national and international research institutions to test new hydrological tools and models, and study the impact of different climate stressors and land-use change on water resources.

A dataset like no other

'There are no other datasets readily available in Australia with such spatial coverage, long duration and high-quality data as Hydrologic Reference Stations. This dataset is a vital resource for undertaking high quality hydrological research. We plan to use it in honours, PhD and postdoctoral research projects that undertake hydrological modelling. This research will improve understanding of the Australian hydrological regime and our ability to predict future droughts and floods, ultimately leading to better use of our limited water resources.'

The Bureau of Meteorology is to be commended for having the foresight to take the leadership in developing this dataset. It will form an important legacy that will enable significant advances in our ability to understand, predict and manage our water resources.'

Mark Thyer, Director of Research
School of Civil Environmental and Mining Engineering
University of Adelaide



GROUNDWATER

Groundwater is a major source of water for many urban and rural communities, as well as industry and agriculture—in some places it is the only source. Groundwater also sustains many rivers and wetlands in dry periods. It is a largely hidden resource and is much harder to measure.

The Bureau has developed a suite of groundwater products to improve visibility of this resource, commencing with standard naming conventions and data collection tools delivered in 2012 and culminating in the release of Australian Groundwater Insight in 2015.

Australian Groundwater Insight is a user-friendly web portal to provide non-experts with groundwater levels, trends, hydrogeological information, licensing and management, and background information all in one place. The website is also mobile-friendly, meaning it is easy to use out in the field on a mobile phone or tablet.

We also updated several other groundwater products in 2015. The Australian Groundwater Explorer, released in 2014, was updated with groundwater level information right across the country. More than 55 000 bores now contain water-level data, which can be viewed as a table or graph and downloaded for further analysis.



The National Groundwater Information System, the database that underpins the Australian Groundwater Explorer, was updated with data from 2013 and 2014. The database now contains bore and bore log data for more than 820 000 bores across Australia. A 3D hydrostratigraphy model and extra hydrostratigraphy logs for the Murray Basin were included in this update, along with production bore data for the ACT.

The National Aquifer Framework, used to standardise the terminology used in groundwater information across the country, was updated in early 2015. It now includes 1048 hydrogeologic units and 49 hydrogeologic complexes, so State/Territory specific names can be standardised prior to loading data into the Bureau's groundwater information systems.

CLIMATE-RESILIENT SOURCES

While groundwater is less responsive to short-term variations in climate and rainfall than surface water, it is still influenced by natural variability over longer periods. Many industries and governments are investing in climate-resilient water sources like desalinated and recycled water, looking to secure reliable water supplies that are less reliant on rainfall.

'Faced with water insecurity, climate-resilient sources can help safeguard Australia's water supply and promote the concept of insurance against future water restrictions. The Climate Resilient Water Sources portal provides new intelligence, freely accessible to the public, on the large number of plants producing desalinated and recycled water.'

Neil Palmer
CEO National Centre of Excellence in Desalination

As well as the five well-known desalination plants for capital cities, there are now hundreds of recycled and desalinated water facilities of varied sizes around Australia providing water for irrigation, industry, waterway health and drinking.

In collaboration with the Australian Water Recycling Centre of Excellence, the National Centre of Excellence in Desalination and CSIRO, we collected information about more than 350 desalination and water recycling plants around the country, including privately and publicly owned and operated facilities.



At the launch of Climate Resilient Water Sources: (from left) Dr Rob Vertessy, Director of Meteorology and CEO for the Bureau of Meteorology; the Hon Bob Baldwin, then Parliamentary Secretary to the Minister for the Environment; Neil Palmer, CEO of the National Centre for Excellence in Desalination; and Dr Mark O'Donohue, CEO of the Australian Water Recycling Centre of Excellence.

In June 2015 we released this information through our Climate Resilient Water Sources web portal. Presenting information about plant location, production capacity, ownership, water use and annual production, this portal can help improve understanding of the important role of alternative water sources so they can play an even greater role in urban and regional water security and supply.

Climate Resilient Water Sources can be used to report against alternative water supply goals and performance—like effluent re-use targets—at a regional, statewide or national level.

It can also be used for planning purposes, such as exploring underutilised sources in a particular area to tap into for a new business—potentially sharing the infrastructure among industries with similar needs.

SHARING AND TRADING WATER

Since the Millennium Drought, Australia's water market has thrived, facilitating the buying and selling of water rights to allow water to be moved and put to more effective use.

We have been working behind the scenes to consolidate a variety of water market information and tools from the former National Water Commission, the Department of the Environment, State water registers, and Bureau websites to offer a single portal for water market information and reporting. This portal will also include water storage and other water resource information to support water market decision-making. We anticipate releasing this portal in the first half of 2016.



'To access reliable data ... that is presented in various formats provides a saving to the department, but more importantly security that the information accessed is reliable and of a high quality.'

'Efficiencies in accessing rainfall data and efficiencies in the early phases of projects regarding hydrology. The ready spatial data access has locked in a reliable level of quality, leading to good decision-making at the important early phases of a project...'

'We can plan better by having more reliable data and trends, which allows us to support irrigators more usefully...'



Dr Rob Vertessy, Director of Meteorology and CEO for the Bureau of Meteorology (far right) asks Neil Palmer, CEO of the National Centre for Excellence in Desalination (centre right) and Dr Mark O'Donohue, CEO of the Australian Water Recycling Centre of Excellence (centre left) to share their thoughts on the importance of alternative water sources to water security at the launch of Climate Resilient Water Sources.

FORECASTING FLOWS



Our aspiration to provide a seamless water forecasting service through hours, days, weeks and months moved ahead in leaps and bounds in 2015.

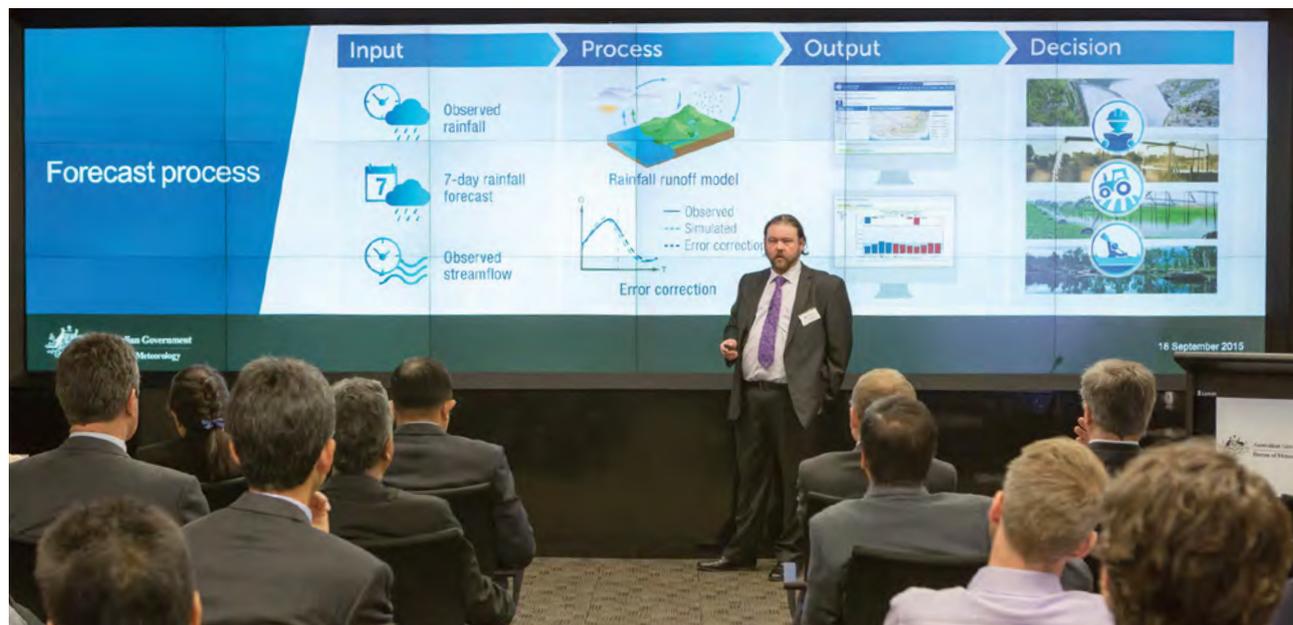
To complement existing flood and seasonal streamflow forecasting services, we officially released a new 7-day streamflow forecasting service. We also substantially expanded the coverage of our seasonal streamflow forecasting service, which is now available in every State and Territory.

SHORT-TERM FORECASTS

The Bureau delivers flood forecasts and warnings for most major rivers in Australia, in cooperation with State/Territory emergency management agencies, water authorities and local councils around the country. While not directly funded through the Improving Water Information Programme, many technology and process developments delivered through the programme have improved our flood forecasting and warning capabilities.

In 2015 we implemented our new Hydrological Forecasting System, which underpins the real-time data management and modelling tools for 7-day streamflow and flood forecasting. We also tested the performance of a range of hydrological models to see which best predicted the results seen for actual rainfall events around the country. We use the Hydrological Forecasting System to provide warnings and forecast floods at 463 locations in 147 catchments across Australia.

We officially released our new 7-day streamflow forecasts service to the public in September 2015, after working with key river users to select forecast locations and test the forecasts through 2014–15.



Bureau hydrologist David Enever explains the 7-day streamflow forecasting process at the service launch.



Managing the upper Murray

Andrew Bishop is a river operator at the Murray–Darling Basin Authority. His team manages the River Murray System including water releases from Hume Reservoir in the upper reaches of the Murray. This water feeds Lake Mulwala, which supplies major irrigation districts in northern Victoria and southern New South Wales.

Flows continuing downstream of Lake Mulwala are managed to meet many other uses, including supporting the riverine environment at sites such as the Barmah–Millewa Forest and along the length of river to the Murray mouth in South Australia.

River operators must take account of natural inflows from tributaries of the Murray such as the Kiewa and Ovens rivers in northern Victoria. This is where the 7-day streamflow forecasting service is of great benefit.

‘Having these forecasts is fantastic! It allows us to more accurately estimate what these natural inflows will be. This means we can meet our Lake Mulwala objectives with more precision by making the right releases upstream. We can also plan for releases in conjunction with natural flows to improve environmental outcomes downstream.’

Andrew Bishop, River Operator
Murray–Darling Basin Authority



Hume Dam on the River Murray, September 2015. (Photo: Murray–Darling Basin Authority)

Combining real-time observations from a national network of rain and river gauges with computer models that simulate rainfall, runoff and river flow, our 7-day forecasts provide guidance on how much water is likely to flow in a river for each of the next seven days.

Forecasts are available to the public for 103 locations in 50 catchments around Australia. We anticipate the public service will be used mostly by farmers and recreational river users planning water-based activities.

A more advanced service is available for registered users, providing hourly forecasts out to seven days to help dam and river operators plan water releases around expected rainfall. This service also includes 23 additional forecast sites—some being tested prior to public release over the next couple of years, while others will remain available only to registered users.

Forecasting tools were developed in collaboration with the Water Information Research and Development Alliance between the Bureau and CSIRO, and then transitioned to the Bureau for further testing and implementation.

SEASONAL FORECASTS

Our seasonal streamflow forecast service was launched in 2010, with 21 locations in eastern Australia. We have progressively increased the coverage of this service every year, testing each forecast location with key stakeholders prior to release. The service now delivers forecasts via a public website for 140 locations covering every State and Territory around the country, with a further 87 locations available to registered users.

These three-month forecasts are used by river managers and water storage operators to plan water supplies, transfers and environmental flows. They are also used as input when determining water allocations each season.

We have also been working on the underlying forecast models. Research conducted in partnership with the Water Information Research and Development Alliance, along with the University of Adelaide and University of Newcastle through Australian Research Council projects, is helping us to develop dynamic models for our streamflow forecasts.

Better water availability forecasts for Melbourne

As the wholesale supplier of Melbourne's drinking water, Melbourne Water is responsible for managing the catchments, treating water and transferring it to water retailers, who then distribute it to users.

Melbourne Water uses the Bureau's seasonal streamflow forecasts:

- to guide water supply planning and operations and manage environmental water resources; and
- as an input in developing the annual *Water Outlook for Melbourne*, which guides water security management and drought-response planning.

The Bureau and Melbourne Water work together to deliver forecasts at the five major inflow locations in the Melbourne water supply network.

By the third day of each month, Melbourne Water provides net inflow data from the previous month at each location. The Bureau feeds the inflow data into its forecast model and issues a seasonal forecast for each location.

The Bureau also provides additional information to demonstrate how often a forecast matches the observed streamflows, giving Melbourne Water and other industry users valuable guidance on forecast performance at different times of the year.



WATER FORECASTING

'Savings of water; flood operations and the safety of people; environmental water delivery. The products are invaluable!'

'Gives policy and planning teams up-to-date, easy-to-understand information regarding flooding in streams across Australia.'

'The products enable informed, timely business decisions in most cases. For my area this is the most important product set.'

'If we know how much water is flowing into our dams, we can get better and earlier predictions of how much water we will have by the end of the rainy seasons, and can support and inform our members sooner and with more confidence.'

'...It is important that these added-value products are prepared by technical specialists to ensure appropriate techniques are applied and data is appropriately interpreted.'

The current public forecasts use a statistical model, forecasting flows based on streamflow that has occurred in the past in similar climatic conditions. A dynamic model simulates changes in soil moisture and streamflow in response to modelled climate inputs—meaning the use of historical data is limited to model calibration.

One- and three-month forecasts based on dynamic models are currently being tested by registered users for around 100 locations, with sites in every State and Territory.

We are investigating ensemble forecasts, providing a range of possible outcomes using rainfall forecasts from the Bureau's operational climate model to drive a dynamic rainfall-runoff model. In parallel, testing is underway to transition to a new climate model, with higher resolution rainfall forecasts which should lead to more accurate streamflow forecasts.

In late 2016 we aim to release a merged forecast based on statistical and dynamic models. This will allow us to further increase the number of forecast sites and improve the accuracy of forecasts at many locations.

While created primarily to help water managers and key water users plan ahead, seasonal streamflow forecasts also provide a good indication of the likely water situation for the agricultural sector and general public. We now provide a monthly video summarising likely streamflow and climate conditions for the coming three months.

FORECASTING FOR THE REEF

Sediment and nutrient-rich water is discharged from catchments into the Great Barrier Reef Lagoon in many locations. Through a collaborative project known as eReefs, the Bureau is building a coastal ocean forecasting system to provide near real-time updates of likely streamflow and pollutant loads from rivers along the east coast of Queensland.

In January 2015 we commenced a three-year project to forecast streamflows and quality for water flowing into the reef lagoon. Our goal is to provide hourly and/or daily streamflow and water quality forecasts up to three days ahead, for 25 catchments with major rivers flowing to the reef.

Timely delivery of river conditions observation datasets through customised and fully automated information systems will also support long-term planning and management of a vibrant and healthy reef ecosystem.

MODELLING AND MAPPING



The Bureau offers a selection of state-of-the-art modelling and mapping tools to help engineers, hydrologists and other specialists visualise the landscape, understand how water moves across that landscape, and estimate the likelihood of rainfall events that might impact infrastructure. These tools provide essential intelligence for managing water resources and community safety.

WATER BALANCE IN THE LANDSCAPE

Knowing how water travels through the landscape, how much is held in the soil at any point in time, what runs off to streams and rivers, and how much filters through to deep drainage and groundwater helps inform decisions for water management and use, particularly in crop production.

In 2015 we released an interactive website to visualise key variables contributing to the Australian Landscape Water Balance—soil moisture, runoff, evapotranspiration, deep drainage and precipitation. We believe this website and the continental-scale water balance model that feeds it are world-first.

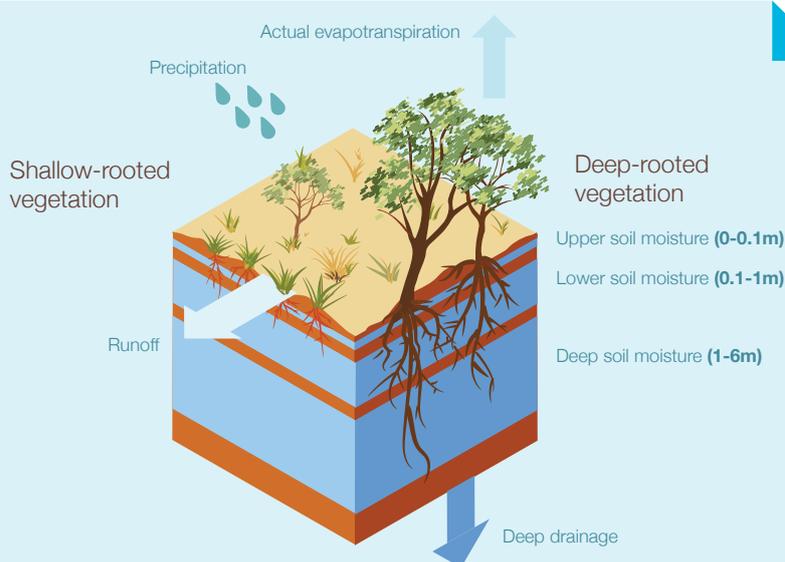
Decision-makers in industry, government and the community can now visualise, investigate and download information about the water balance by day, month or year, and at every scale between point location, catchment and the entire continent.

The model behind the website was developed through our Water Information Research and Development Alliance with CSIRO. Read more about it in the 'research and development' section of this report.

The model is used as an input to other Bureau products, including our National Climate and Water Briefings, National Water Account, Special Climate Statements, Climate Outlooks and (internal) weather, climate, flood and space weather updates.

The model

The Australian Landscape Water Balance website provides estimates of water fluxes and stores in the Australian landscape. It is based on a model that simulates the flow of water through the landscape—through the vegetation and soil—and then out again through evapotranspiration, runoff or deep drainage to groundwater as shown in the figure.





‘The Bureau of Meteorology played a critical part in our Rowallan Dam Upgrade project. We could not have excavated two portions of the dam right down to bedrock and reconstructed them without the confidence that we could manage the flood overtopping risk during construction. We engaged the Bureau to provide a special service to give us extreme rainfall forecasts and elaborative briefings to understand potential major rain events.’

Andrew Pattle, Principal Engineer
Civil & Dam Safety, Hydro Tasmania

The landscape water balance model is also used outside the Bureau in a range of water and climate applications. For example, the Victorian Department of Primary Industries use the soil moisture model to summarise climatic conditions and help prepare their seasonal climate outlooks. Preliminary analysis shows that the AWRA-L soil moisture model output better matches the patterns observed through the Department’s soil moisture monitoring network than previous models.

DESIGNING WATER INFRASTRUCTURE

Used to design infrastructure like stormwater drains, roofs and gutters, levees and dams, design rainfall estimates are a vital tool in every engineer’s toolkit.

In mid-2013 we released new design rainfall estimates for frequent and infrequent rainfall events, known as Intensity-Frequency-Duration design rainfalls—the first output in a broader project with Engineers Australia to update *Australian Rainfall and Runoff: A Guide to Flood Estimation*, which was last released in 1987.

In addition to 30 years of extra rainfall data and an additional 2300 rainfall stations, the new design rainfall estimates also use contemporary statistical analysis and techniques to provide more accurate estimates for Australia.

Over the past 18 months we have been developing design rainfall estimates at either end of the spectrum of rainfall frequencies. We’ve been working on estimates for very frequent rainfall events—those likely to occur between two and 12 times every year—which are used in water-sensitive urban design and some stormwater design. We’ve also been developing new estimates for rare rainfall events—statistically likely to occur less than once every 100 years—used for designing bridges and assessing the adequacy of dam spillways. These estimates will be released in 2016.

MAPPING WATERWAYS AND FLOWS

The Australian Hydrological Geospatial Fabric, or Geofabric, is a specialist geographic information system mapping the connections between water features across the Australian landscape. It is like a roadmap for rivers, lakes, water storages and catchments. Being able to map how water is moved, used and stored throughout the landscape is vital for the effective management of water resources.

First released in 2010, we continue to develop the Geofabric each year, improving the resolution of the maps and increasing the number of mapped features.

In 2015 we released Geofabric version 3 for the Pilbara–Gascoyne drainage division—the first of 13 drainage divisions to have version 3 data over the next two years. The finer scale of version 3 delivers improved catchment areas that better reflect the reality of regional catchment boundaries. It also maps more rivers, lakes, dams and water tanks than previous versions

We also released a sample Geofabric toolset to help users:

- create custom sub-catchments and stream link networks within those sub-catchments;
- export user-created stream links in a suitable format for the commonly used Unified River Basin Simulator runoff-routing model;
- set preferred flow paths for complex divergent drainage networks to use in hydrological modelling of rivers and catchments with many potential flow paths, like the River Murray as it flows into and through the Barmah–Millewa Forest; and
- download Water Data Online time-series data for multiple stations in bulk, to use in hydrological models for reporting or forecasting, and visualisation of historical streamflows.

RESEARCH AND DEVELOPMENT



The products and services delivered through the Bureau's Improving Water Information Programme are driven by targeted, high-quality research and development.

Most of this research is completed through our Water Information Research and Development Alliance with CSIRO. Here is a brief summary of some of the major projects currently being delivered through the alliance.

STREAMFLOW FORECASTING RESEARCH

Work continues behind the scenes to further develop the models behind our 7-day streamflow forecasts. Work is well-advanced on an upgraded hydrological modelling package which includes more efficient data handling and enhanced sub-catchment models, and a new streamflow bias correction model which significantly improves the forecast skill and supports ensemble forecasts.

Advanced modelling techniques were developed for ephemeral catchments, which are difficult to model due to their short-lived and intermittent flows.

Further research was conducted on evaluating ensemble rainfall and streamflow forecast performance and recommendations will be applied to the next generation streamflow forecasting system.

We have been improving our seasonal water forecasting capabilities by developing methods to increase the accuracy and reliability of the forecasts, expand the coverage, better integrate climate forecasts, and provide forecasts beyond three months.

In addition, we are investigating separating the three-month forecasts into individual months in response to stakeholder feedback.

We are also working on reducing processing time for producing the forecasts, allowing the forecasts to be issued faster once input data is collected.



Dr QJ Wang, Senior Principal Research Scientist for Land and Water at CSIRO, shows the latest research developments in seasonal streamflow forecasting to Bureau's Manager of Extended Hydrological Prediction, Dr Narendra Tuteja, and hydrologists Dr Christopher Pickett-Heaps and Andrew MacDonald.



'I have been blown away by how perfectly [the landscape water balance] website answers the most needed questions for farmers and makes the data so easily accessible. Having access and knowing lots of details about rainfall is one thing, but the added information about soil moisture really completes the whole story!'

Warwick Holmes
Engineer

WATER BALANCE MODELLING

The Australian Water Resources Assessment Modelling System is a suite of models to simulate water movement through the landscape, river systems and catchments. Following development and testing of these models over recent years, several elements of this modelling system were transitioned into operations in 2015.

An improved landscape component of the model was implemented right across continental Australia. When tested against peer models, it performed better than other continental-scale models. It also performed as well as, or better than, individually calibrated conceptual models, supporting more timely and efficient catchment-scale rainfall-runoff modelling.

The landscape model is used behind the scenes in many Bureau, government, industry and research applications, and also feeds an interactive Australian Landscape Water Balance portal through the Bureau's public website.

The river component is being implemented across the Murray–Darling Basin National Water Account region for the 2015 account. Performance of this regionally calibrated model within the Murray–Darling Basin catchments was found to be comparable to earlier models calibrated at each river reach.

The Australian Water Resources Assessment Modelling System recently won the Research Innovation Award in the Australian Water Association's ACT awards. The award recognised the innovative scientific research that underpins the modelling system, as well as the positive collaboration between CSIRO and the Bureau of Meteorology (some members of the Bureau team with the award on the right).

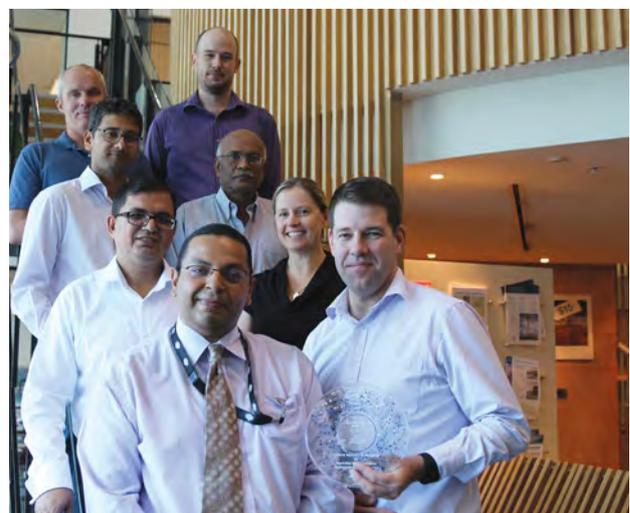
WATER INFORMATICS

Before data standards are implemented, they are developed and thoroughly tested through our research and development programme. Our recent focus has been on developing international standards for data exchange and linked data.

Over the past 18 months, we led the development or significantly contributed to three proposed international standards:

- GroundwaterML2.0;
- WaterML2.0: Part 2 (Ratings, gaugings and sections); and
- TimeseriesML.

The Bureau provides a secretariat role to the Australian Government Linked Data Working Group—a technology-focused group looking at evolving linked data issues for the federal government. Linked data standards and technologies provide the foundation of future web-based data services. We are using linked-data technologies to publish current water observations and link them to previously unconnected web-based data sources.



COMMUNICATION AND ENGAGEMENT



The wide range of water information products and services are only valuable if they are used by industry and government decision-makers. We use a variety of communication and engagement methods to ensure potential users know about these products and services and are inspired to use them, and existing users get the most value out of these resources.

SHARING WATER INFORMATION

Our main delivery mechanism is the Bureau's public website, at www.bom.gov.au/water—attracting more than 830 700 unique page views in 2015.

The most frequently accessed products throughout 2015 include water forecasting tools (seasonal streamflow forecasts and flood forecasts and warnings), and engineering inputs for designing water infrastructure (Intensity-Frequency-Duration design rainfall estimates).

We actively share news and monthly forecasts using email newsletters and updates. Five editions of our enGauge e-newsletter in 2015 delivered news from our water, climate, environment and research programmes. By the end of 2015 more than 6000 people were subscribed to this e-newsletter.

Our monthly emails sharing seasonal streamflow forecasts continue to be popular—at the end of 2015 more than 2600 people were subscribed, a 20 per cent increase on 2014 subscribers. We also issued two editions of Groundwater News, which had 1100 subscribers by the end of the year—more than twice as many as at the end of 2014.

In addition, we sent updates to subscribers and registered stakeholders about the public release of the 7-day streamflow forecasts service and changes to water restrictions data collection tools.

The Bureau's regular climate updates and outlooks are well subscribed by water stakeholders due to the inherent linkages between rainfall, temperatures and water availability.



Director of Meteorology, Dr Rob Vertessy explains how the Bureau's water products add value to those provided by other organisations at OzWater'15. (Photo: Australian Water Association)

ENGAGING STAKEHOLDERS

We completed our nationwide series of information sessions, which commenced in 2014, with a briefing to senior government officials in Canberra in February 2015. We used the opportunity to demonstrate progress of the Improving Water Information Programme and provide a preview of products and services to be finalised and released in 2015. Subsequent discussions generated many ideas and opportunities for increasing awareness and uptake of the programme's offerings.



Our monthly Climate and Water Briefings in Canberra continue to inform decision-making among federal and ACT government agencies, along with government agencies in other locations who watch via video connection. Around 40–60 people attend each month, representing around 40 organisations.

In addition to regular content covering recent conditions and outlooks, the briefings also featured El Niño outlooks and impacts, pre- and post-severe weather season summaries, 2015 Australian and global reviews, and content from new water products and services such as Climate Resilient Water Sources, 7-day streamflow forecasts and the Australian Landscape Water Balance.

We continue to work closely with stakeholders through consultative and advisory committees to help develop water information products and services. We'd like to thank all the members for their valuable time and input.

Our project teams liaise directly with key stakeholders, data providers and users throughout the year, through the various phases of product development and delivery. Feedback from these meetings informs improvements, communications, and selection of priority regions and sites for our products and services.

Bureau staff attended and presented at many conferences around the country, including OzWater'15, the AWA Innovation Forum, the International Riversymposium, the Australian Groundwater Conference, ModSim, and the Hydrology and Water Resources Symposium. In addition to presenting to targeted audiences, we interacted with users and potential users of the Bureau's water information products one-on-one at trade stands, and other networking opportunities.



Assistant Director, Water Forecasting, Dr Dasarath (Jaya) Jayasuriya and Manager, Seasonal Streamflow Forecasting, Dr Paul Feikema demonstrate products to members of the urban water industry at a Water Services Association of Australia forum in August 2015.

As well as increasing awareness and uptake of our water information products, these discussions help us understand user needs and further develop our service offerings.

We have also been working with industry associations to raise awareness and use of the Bureau's products among members to help with their operational and planning needs.

INTERNATIONAL RELATIONS

International cooperation and information-sharing opportunities help enhance both the Bureau's water information and forecasting expertise and that of the countries we work with.

In 2015, we hosted delegations from Myanmar, USA (California) and China, as well as visiting Vietnam as part of an Australian delegation to Vietwater, organised by the Australian Water Association.



Deputy Director, Environment and Research, Graham Hawke addresses the California Foundation on the Environment and the Economy delegation roundtable in October 2015.

VIDEO SUMMARIES

Our monthly Climate and Water Outlook videos are a popular summary of recent and likely upcoming conditions for technical and public audiences. While the videos attract, on average, more than 14 500 views per month through the Bureau's website and social media channels, this is eclipsed by broadcasting them on ABC Television's *Landline* program, reaching approximately 500 000 viewers each month.

In addition to these monthly updates, we released videos explaining our new 7-day streamflow forecasts and summarising the 2013–14 National Water Account.

We also created a series of short product summary videos to use at conference trade stands. These one-minute videos, along with our longer outlook and explainer videos, are helping demonstrate the breadth of the Bureau's water products and how they are helping industry.



ABC's *Landline* includes the Bureau's Climate and Water Outlook videos every month on television and its website.

MEASURING THE PROGRAMME'S VALUE

An independent analysis of the programme's value was conducted in the second half of 2015.

The analysis estimated \$67–287 million in annual benefits as a result of the programme at the time of the survey. This did not take into account a likely increase as new products were released or updated during the second half of 2015.

Key benefits identified by users included better investment decisions, risk management and operational decision-making, and consistency across regions.

Irrigators, water utilities and hydroelectricity generators responsible for moving significant water resources across Australia were able to reduce production costs by using streamflow forecasts. The value of streamflow forecasts is greatest for users that lack in-house capability, such as rural and regional water supply companies and irrigators.

Rural investors use the Bureau's water products and services to evaluate risk and inform water trade and investment in farms and rural property. Products also assist farmers and irrigators to manage risks associated with climate variability.

Among government users, the CSIRO uses the Bureau's water information to substantially reduce costs of research on water availability and agricultural development and on work to inform assessments of the impacts of coal seam gas development.

The Murray–Darling Basin Authority uses a large number of products to inform operations and policy development, and places a high value on the Bureau’s independent, authoritative and publicly available data.

The study also found the Bureau’s flood forecasting and warnings indispensable to State and local government. Additionally, design rainfalls—which help ensure infrastructure such as flood levees, dams, gutters and stormwater drains are designed to meet safety requirements—are used widely to support infrastructure investment decisions.

We also conducted an online survey of stakeholders and product users in late 2015. We received responses from 530 people, representing 270 organisations across Australia.

Eighty-six per cent of respondents said the programme is relevant to their activities and 52 per cent of users said the products are having a strong or major impact on their activities.

Stakeholders are using the programme’s products and services for monitoring, planning, forecasting reporting and compliance purposes.

Water data and water forecasting tools were used by 73 and 68 per cent of respondents respectively, with water status products and services following closely with 63 per cent. While water information standards were used by a much smaller proportion of respondents (25 per cent), they were seen to have an impact on the activities of 79 per cent of those users.

WHAT DO YOU VALUE MOST ABOUT THE IMPROVING WATER INFORMATION PROGRAMME?

‘Access to consistent national data. In particular it is a pathway for others to access the information, which leads to more informed conversations.’

‘Independence and professionalism. Agencies responsible for water management can sometimes be accused of having vested interests and ‘hiding’ information. Having the suite of professional products prepared by BOM gives confidence to users and supports agencies achieving their goals.’

‘Increased availability of data and synthesised statistics; the development of user-friendly online tools.’

‘Being able to find so much information at the one site (one-click BOM website). Also the ability to be able to sign up for notifications, newsletters, etc., (saves me having to remember to log onto the BOM website).’

‘I am interested in the issue of water in this dry country. The information has generally been scattered but the Bureau is overcoming this.’

‘I really appreciate the fact that the data is becoming more readily available in an easy-to-access format.’

‘Good information on water and how it impacts upon my department’s programmes.’

‘Improved coordination of multi-jurisdictional datasets. Availability of new products.’

‘Quick access to key indicators. Good infographics to represent data, which can be useful when trying to identify trends or previous period comparisons quickly.’

2007–2015 ACHIEVEMENTS



Detailed water accounts covering more than 75% of Australia's population and 70–80% of water use



Updated Intensity-Frequency-Duration design rainfall estimates for designing gutters, culverts, bridges and drains



Insight into Australia's water resources—availability and use, climate influences and long-term trends



Location, production and use details for 350+ recycled and desalinated water sources



Regional data and mapping of water availability and use, climate influences and trends



Streamflow trends at 222 Hydrologic Reference Stations, updated every two years



Streamflow forecasts for the next 7 days at 103 sites across 50 catchments



Monthly review of streamflow and rainfall at 220+ sites



Forecast streamflow over 3 months for 140 sites (in every State and Territory)



Daily updates of streamflows at more than 3200 monitoring sites



One-stop shop to explore groundwater resources nationwide



Daily reporting of surface water storage volumes in 310 publicly owned lakes, reservoirs and weirs



Groundwater information for 820 000+ bores, including water-level data for 55 000+ bores



Tracking and reporting of water restrictions across major metropolitan and regional urban centres



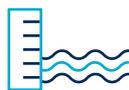
3D models for 9 major aquifers around Australia



Water markets reports provide transparency around water rights and trading



Hydrological models developed by scientists at Bureau of Meteorology and CSIRO



463 projects delivered to upgrade data providers' hydrological monitoring systems nationwide



Interactive maps of soil moisture, runoff, precipitation, evapotranspiration and deep drainage across Australia



National and international standards to effectively share and compare water data



Digital database of surface and groundwater features for mapping spatial relationships between hydrological features



Australian Water Information Dictionary, defining more than 1400 terms



More than 33 million data and metadata files received from 178 providers, containing more than 4 billion time-series observations



The world's first water accounting standards, based on financial accounting models



Water observations covering 10 categories and 95 sub-categories



More than 6000 people receive regular updates about the water situation, forecasts and information tools



Water information accessed 5 122 000 times via website since it launched in 2010



Monthly climate and water briefings inform government planning and decision-making



Twenty-four videos watched more than 138 000 times since our first video in 2011



86% of respondents in a 2015 survey found the programme relevant to the activities undertaken by them, their team or organisation



Every month approximately 500 000 people see our climate and water outlook on ABC Television's *Landline*



\$67–287 million in annual benefits delivered through the use of water information products

