Abstract

Access to nationally consistent information is essential to support informed decision-making about Australia’s vital groundwater resources. However, until now it has been difficult to depict a seamless national picture of groundwater resources and frame groundwater issues at a national scale. This is because groundwater data is typically managed locally without consistent format or terminology. Under the Commonwealth Water Act, the Bureau of Meteorology now collects, standardises, stores and analyses groundwater information from Australian lead water agencies to ensure the best available information is on hand to help understand this complex and largely hidden resource. One of the main objectives of the Bureau in the last few years has been to adopt a collaborative approach and work closely with State and Territory governments and other Commonwealth agencies to develop a consistent representation of Australian groundwater that is accessible and can be easily downloaded. This has resulted in the Bureau’s Groundwater Information Suite.

Key words: data management, groundwater, stakeholder engagement

INTRODUCTION

Groundwater is a critical resource for many Australian urban and rural communities, providing water for domestic use, industry and agriculture. In some places it is the only water available (Harrington & Cook 2014). Groundwater also sustains many rivers and wetlands during dry periods.

Nationally consistent groundwater information is needed to underpin national decisions. However, it has been difficult to depict a seamless national picture of groundwater resources and frame groundwater issues at a national scale. This is due to the distributed nature of groundwater management across the various levels of government as well as private agencies. The imperative for improved groundwater information at a national scale has been driven by the need for a national baseline picture on a range of groundwater management and resource issues from which future progress could be measured (NWC 2006). Evidence-based policy making relies on the availability of information that is credible, legitimate and salient (Robinson et al. 2010).

Under the Commonwealth Water Act 2007 (Government of Australia, 2007), the Bureau of Meteorology is tasked with a range of functions which require it to collect, hold, manage, interpret and disseminate Australia’s water information, including groundwater. This led to 178 organisations supplying a vast variety of water data to the Bureau. Currently the Bureau receives approximately 15,000 data files daily. In turn, this has created an extraordinary task for the Bureau to sort, identify and ingest the data relevant to groundwater from within these files. Additionally, the Bureau must bring a common terminology to this data and place it into the relevant hydrogeological framework. Furthermore, the Water Act 2007 states that this data should be made available to the Australian public.
To overcome this monumental challenge the Bureau has adopted a collaborative approach and worked closely with State and Territory governments and other water agencies to develop a consistent representation of groundwater that the Australian public can easily access. This strategic guidance and technical input has resulted in the development of a comprehensive range of groundwater information products. This paper presents some of the challenges and limitations encountered in supporting the Bureau’s role to standardise and collate Australian groundwater data and report on groundwater resources. The vision is to develop a consistent representation of groundwater across Australia using the knowledge and experience already available from groundwater experts across Australia.

AUSTRALIAN GROUNDWATER DATA

The Bureau maintains and develops Part 7 of the Water Regulations (Government of Australia, 2008), established by the Water Act 2007 (Government of Australia, 2007), which deals with water information. The Regulations set out the detailed requirements of the water information framework, defining the water data providers, and the time and format in which the water data must be given. Water data is sent to the Bureau in various formats, but the preferred format is the Water Data Transfer Format (WDTF) developed in partnership with CSIRO, with the intention of standardising the water data format. While the development of WDTF has gone a long way to facilitating the process of water data transfer in Australia, adoption and correct application of WDTF remains an issue. Groundwater data is inherently complex and important metadata for groundwater is not natively included within WDTF.

A major challenge for the Bureau in building a national groundwater dataset was that the States and Territories use local terminology to describe aquifers and aquitards. These differences can be problematic, particularly when examining water basins that span multiple States and Territories. Following this, the Bureau in partnership with State and Territory water agencies and the National Water Commission developed the National Groundwater Information System (NGIS), which provides a hydrogeological classification system that improves representation of groundwater resources at a national scale. The NGIS project also supports each State and Territory to develop a National Aquifer Framework (NAF) to standardise the naming of aquifers within the NGIS. The NAF and the NGIS are part of the Water Regulation categories 2d and 2e and are updated on an annual basis.

Currently groundwater data relating to levels, abstraction, licences for groundwater use and salinity (categories 2a, 5 h, 6f and 9b respectively) are sent to the Bureau by water agencies throughout Australia. When groundwater data is submitted to the Bureau it is standardised for terminology and format, and then ingested in the NGIS resulting in standardised groundwater data for more than 850,000 bores across Australia. Bore-by-bore analysis of groundwater level and salinity is also undertaken, with this data available to be visualised and downloaded from the Bureau’s website. Groundwater data and analysis are used in the Bureau’s annual reports mandated by the Water Act 2007 such as the National Water Account and Water in Australia. The flow of data from state databases to published products is illustrated in Figure 1.

Groundwater data use and methods are reviewed by a technical reference group, comprised of groundwater experts from State and Territory water agencies and national scientific organisation such as Geoscience Australia and other commonwealth agencies. The reference group ensures the quality of each of the groundwater products by approving all content. This review guarantees no duplication of efforts amongst the agencies by reusing existing knowledge and sharing experiences.

Groundwater availability and suitability for use across Australia is determined by physical constraints such as aquifer yield, salinity, and groundwater management rules. State and Territory
agencies set limits and issue licences for the take of groundwater in order to distribute the resource between the Australian community and the environment, while also taking into consideration cultural aspects of the resource. To support planning for the future, there is a need to consistently report how groundwater conditions are tracking across the nation.

MAKING AUSTRALIAN GROUNDWATER DATA ACCESSIBLE

The Bureau works closely with State and Territory governments and other Commonwealth agencies to develop the groundwater products to track groundwater conditions and understand groundwater data availability across Australia. This has resulted in the development of a comprehensive range of groundwater information products, which have not previously existed at the national scale. The Bureau’s suite of groundwater information products includes:

- Australian Groundwater Explorer
  - National Groundwater Information System (NGIS)
  - National Aquifer Framework (NAF)
- Australian Groundwater Insight
- Atlas of Groundwater Dependent Ecosystems (GDE)

All of the Bureau’s groundwater products are available to the public, from the groundwater part of the Bureau’s website [http://www.bom.gov.au/water/groundwater](http://www.bom.gov.au/water/groundwater).

Groundwater is often considered the ‘poor cousin’ of surface water regarding data availability, however, in Australia there is wide-scale monitoring of groundwater as shown by the Bureau’s Australian Groundwater Explorer. This interactive mapping application allows users to search and view groundwater level, salinity and rainfall trend data as tables and graphs (Figure 2). Data can be downloaded in several formats: ESRI File Geodatabase, CSV, ESRI Shapefile and KML. The Explorer is a valuable tool for technical experts in government, research, education and industry sectors. For example, a consultant can easily access standardised groundwater data to use in an environmental impact assessment of a mining application. Data used in the Explorer is available to GIS experts to be downloaded as a spatial database, the NGIS.

Although groundwater levels and salinity measured from bores are two of a few direct measurements readily available to analyse changing groundwater resources, it is important for a national...
overview to assess the long-term trend in groundwater levels and salinity across an aquifer or management area, rather than any short-term localised changes e.g. due to seasonal pumping. Because of this, trend in levels and groundwater salinity are presented in the *Australian Groundwater Insight* together with groundwater management information to identify changes in groundwater conditions (Figure 3). This product is a user-friendly map application designed for non-experts in government, policy development and the general public. The Insight shows hydrogeological information alongside information about licences, entitlements, bore density and groundwater management areas.

The *GDE Atlas* is another mapping application, providing a comprehensive national inventory of ecosystems that depend on groundwater (Figure 4). It presents the location and detailed ecological and hydrogeological information about these important ecosystems. It includes aquatic ecosystems, such as rivers, wetlands and springs; terrestrial ecosystems including vegetation; and subterranean ecosystems, such as caves and aquifers. The Atlas is a valuable source of information for experts in government, research and industry sectors who work with ecosystems. It supports the consideration of ecosystem groundwater requirements in natural resource management, water planning and environmental impact assessment. For example, a researcher could use the data to model the impact of groundwater salinity on wetlands.

**THE VALUE OF COLLABORATION**

The Bureau created a suite of nationally consistent groundwater data and information products thanks to the support and collaboration with groundwater experts across the nation. The Suite presents physical information on aquifers, groundwater salinity and GDE, with management data providing background context to the groundwater level and salinity data and analysis. These products were developed targeting a variety of audiences. Government, industry and the general public can use the Suite to inform decision-making and research about groundwater resources.
The Bureau's suite of groundwater products is valuable to both technical and non-technical users, such as resource managers, farmers, property owners, policymakers, consultants, researchers, scientists and interested public. For the first time, decision-makers in industry, government and the community have easy access to comprehensive, nationally consistent information on groundwater from standardised data to in-depth analysis to support sustainable use of the groundwater resource.

**Figure 3** | The Australian Groundwater Insight showing the 20 year average groundwater salinity for the Great Artesian Basin (middle aquifer group). Accessible at [http://www.bom.gov.au/water/groundwater/insight](http://www.bom.gov.au/water/groundwater/insight).

**Figure 4** | Screenshot of the GDE Atlas showing the location of aquatic GDEs as determined by regional studies (purple) and national assessment (blue). Accessible at [http://www.bom.gov.au/water/groundwater/gde](http://www.bom.gov.au/water/groundwater/gde).
across the nation. Using a simple and transparent assessment of groundwater levels and salinity combined with the location of GDE and physical hydrogeology as well as information on groundwater management, an answer to how groundwater conditions are tracking across the nation is now available.

It is important to highlight that all this would not have been possible without the collaboration and knowledge and data shared by states, territories, and other commonwealth and local water agency groundwater experts. This effort has shown the value both of local understanding of groundwater issues and the need for an integrated platform at national scale. The most efficient way to produce the groundwater suite of information is through collaboration where no duplication of capability occurs, but rather sharing of knowledge for an improved outcome.

FUTURE OUTLOOK

The Bureau has recently updated the GDE Atlas, integrating new state and regional datasets. These updates are available through the on-line application. The update is part of the Bureau’s ongoing focus on providing the provision of water and environmental information for Australia to support a transparent management of resources. The remaining challenges for groundwater data are: an increase in the frequency of data updates from annual to monthly, improved quality control of data, regular reporting of groundwater use and better integration of products.

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