NSW GOVERNMENT | Natural Resources Commission

Review of the water sharing plan for the NSW Great Artesian Basin Groundwater Sources 2008

June 2018

Enquiries

Enquiries about this report should be directed to:

Name	Amy Dula
Phone	(02) 9228 4635
Fax	(02) 9228 4970
E-Mail	amy.dula@nrc.nsw.gov.au
Postal address	GPO Box 5341, Sydney NSW 2001

List of acronyms

CSG	Coal seam gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DoI-Water	Department of Industry - Water
GAB	Great Artesian Basin
NSW	New South Wales

Cover image: Peery Lake full of water in 2012. Photo taken by Dinitee Haskard, Office of Environment and Heritage. Available at https://www.nationalparks.nsw.gov.au/things-to-do/picnic-areas/peery-lake-picnic-area.

Document No. D18/1725

ISBN: 978 1 925204 33 9

Table of Contents

1 Executive summary

The Great Artesian Basin (GAB) is one of the most significant water resources in Australia, underlying approximately 22% of the continent, with a total of 207,592 square kilometres (or approximately 12%) falling within the NSW State boundaries.[1] The Water Sharing Plan for the GAB groundwater, is an essential mechanism for balancing water use within the system between community, industry and the environment.

The Natural Resources Commission has a statutory responsibility to review Water Sharing Plans due to expire and provide advice to the Minister for Regional Water whether to extend a management plan that deals with water sharing or make a new management plan. The Commission has reviewed the *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008* (hereafter referred to as the Plan) consistent with this responsibility. The Commission recommends that the Plan be replaced with a new management plan in order to:

- clarify the language of the plan to ensure that current over entitlement in the recharge sources is transparent to users and allows water users to manage risk to future allocation
- update the calculations and assumptions underlying the plan to ensure that it reflects best available current knowledge, including the review and update of:
  - the annual extraction limits for GAB artesian and recharge groundwater sources
  - the boundaries of the groundwater sources within the plan
  - identification of high priority groundwater dependent ecosystems
  - set-back distances for water supply works located around high priority groundwater dependent ecosystems
  - amounts required to meet basic landholder rights
  - estimates of future needs for GAB groundwater sources to ensure critical town water supply and the adaptive management of water resources for climate change impacts
- enhance the identification and protection of Aboriginal cultural values
- update the requirements related to metering and reporting in line with Government policy
- improve overall plan clarity including the establishment of logical links between objectives, strategies and performance indicators.

The Commission also suggests that the Department of Industry – Water (DoI – Water) consider merging the Plan with the *Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources 2011*. This is in line with advanced understanding of hydraulic connectivity between groundwater sources. It would also avoid 'grey areas' in applying plan management, where the current boundary separating the two sharing plans is not geologically accurate. Merging of plans would improve plan clarity for water users and simplify plan administration.

The Commission assessed the contribution of the Plan to achievement of LLS State Priorities, which relate broadly to triple bottom line outcomes. These are consistent with the objectives of the Plan. It is difficult to assess the extent to which the Plan has helped achieved many of the objectives given the limited monitoring and evaluation. However, one of the key objectives of

[1] Great Artesian Basin Coordinating Committee (2009). Great Artesian Basin Strategic Management Plan: Progress and Achievements to 2008.

the Plan relates to restoring pressure in the artesian systems through improvements in water efficiency by water users. Significant progress has been made in improving pressure through the Cap and Pipe the Bores program. The restoration of bore drains and controlled flow of artesian bores has significantly reduced the volume of water wasted under traditional bore construction and distribution systems. Improved pressure in the artesian sources within the Plan is critical for ensuring the sustainability of water usage, and protecting and revitalising groundwater dependent ecosystems.

Overall the Plan has supported productive communities, with nearly all licence holders currently receiving at or near 100% of their entitled allocation throughout the life of the Plan. However, future demands are likely to impact access in the Eastern Recharge groundwater source, where demand is currently at or exceeding the long-term average annual extraction limit. Further, it is noted that the Eastern Recharge and Southern Recharge groundwater sources are at, or exceeding entitlement relative to the long-term annual net recharge volume, which may result in a requirement to reduce allocation in the event of activation of 'sleeper licences'.

While the Plan recognises the importance of cultural values, it is does not provide clear direction in regards to specific values or locations it aims to protect, or how they will be protected. There are significant cultural heritage values throughout the GAB and engagement with the Aboriginal community will be critical in developing a new plan that adequately addresses protection of Aboriginal cultural values.

The GAB system is highly complex and there have been substantial advances in the understanding of the Basin since the development of the Plan in 2008. This new information has implications for a range of important aspects within the Plan. These include the revision of sustainable extraction limits for artesian and recharge groundwater sources and the administrative boundaries established for different groundwater sources identified within the Plan. The revision of these Plan provisions will impact future management of GAB groundwater sources and facilitate its ongoing sustainable use.

The Commission recognises that preparing a new plan and addressing the recommended changes will be a considerable undertaking given the complexity of the system. Development of the new plan is likely to take considerable resources and the process should be started in a timely manner.

Effective implementation of some complex areas of the Plan have been overly reliant on experienced DoI – Water staff with sufficient knowledge of the system to manage groundwater resources, rather than this being facilitated through clear Plan provisions. Further, areas of confusion or potential inability to comply with the Plan, even when identified by staff, have not been addressed to date through an Amendment process. In implementing the new plan consideration should be given to ensuring sufficient oversight of the overall implementation and compliance with the plan to ensure any concerns are addressed in a timely manner.

The Commission also recognises that following any update there will remain uncertainties in revised estimates of the recharge pathways, the recharge quantities, the age of extracted water, and the time required to fully realise the impacts of both historical and current groundwater extraction. Resolving these uncertainties to make the most efficient and sustainable use of the GAB water resources requires ongoing and expanded metering of water use, pressure monitoring and geochemistry monitoring.

Table ES 1 below provides detailed recommendations for changes that the Commission feels are warranted to create an improved water sharing plan for the GAB.

Table ES 1: Recommendations

1. The new plan should establish revised sustainable pressure estimate equivalents, planned environmental water provisions and long-term average annual extraction limits to recognise: ▪ improved knowledge of annual recharge and flux in artesian groundwater ▪ data on water use efficiencies made through the Cap and Pipe the Bores program ▪ data from ongoing projects that will improve understanding of GAB artesian pressure ▪ a need for greater clarity and transparency of total extraction limits ▪ apparent errors in the description of the calculation for planned environmental water for the artesian groundwater sources ▪ impacts of climate change in estimates of recharge to facilitate adaptive management of GAB recharge groundwater sources.
2. The Plan should be revised to transparently indicate the current entitlement for water available for allocation to: ▪ provide clarity for water users that 1 share does not equate to 1ML of licensed entitlement for aquifer access licences. ▪ include provisions to allow for updating of licensed entitlement within a groundwater source when appropriate (e.g. due to cancellation and suspension of licences, controlled allocations and improved knowledge of water sources.)
3. DoI – Water should consider the adequacy of the current extraction limit compliance trigger for maintaining sustainable extraction in the event of significant short-term activation of sleeper licence entitlement, and if appropriate amend the trigger in the new Plan.
4. To improve identification and protection of groundwater dependent ecosystems in the new Plan DoI – Water should: ▪ Complete the survey of artesian springs to ground-truth and nominate groundwater dependent ecosystems to be protected within the new Plan. ▪ Establish appropriate set back distance of water supply works based on best available scientific evidence to avoid impacting high priority artesian springs or unduly restricting works approvals. ▪ Update Plan provisions to establish an approach to rehabilitation of water supply works that pre-date set-back distances under the GAB Groundwater Plan to adequately protect high priority artesian springs. It is noted that this should be carried out following completion of the survey.
5. To better reflect system take and ensure ongoing sustainability of extraction in the new plan DoI-Water should: ▪ Apply the best available methodology to estimate stock and domestic requirements under basic landholder rights. At a minimum this should incorporate climate data and availability of non-groundwater sources to improve reliability of stock and domestic requirement estimates.

- Align provisions for local utility access licences with other groundwater water sharing plans to allow for ongoing town water supply.
- Provide greater transparency around water taken through aquifer interference by implementing measures to allow for identification of water allocated for aquifer interference separate from water extracted out of the system and removing aquifer interference access licences as a licence category in the Plan.
- Consider the extent to which Division 6 (Controlled activities and aquifer interference activities) of the Act should be applied in the new Plan.

6. In developing the new plan, DoI-Water should consult with Aboriginal communities to identify groundwater sites of Aboriginal spiritual, social and customary value, and clarify the objectives and performance indicators in relation to cultural values. The new Plan should include provisions that identify (or nominate a database location) for cultural values within the GAB Groundwater Plan area.

7. Administrative boundaries should be updated by DoI – Water in the new Plan to:

- Redefine the boundaries of the Warrego groundwater source as defined in Schedule 2 based on latest available knowledge.
- Re-classify registered bores impacted by the change in the Warrego groundwater source boundaries and notify affected licence holders.
- Merge the NSW GAB Shallow and GAB Groundwater Plan in recognition of the constraints imposed by continuing to separate the Plans at the currently defined boundary of 60m, and to assist in groundwater management across administrative boundaries.

8. To improve overall clarity of the new Plan DoI – Water should:

- implement a simplified template and consistent terminology
- clarify aspects of the Plan that create confusion based on input from stakeholders, including extraction limits, Plan boundaries and links to other water sharing plans.
- update the objectives, strategies and performance indicators in the new plan. These should be logically linked and specific to enable the monitoring and delivery of plan outcomes.

9. In developing the new plan, DoI- Water should complete current efforts to:

- Apply metering policies developed under the Water Reform Action Plan to improve assessment of impacts and available water determinations enforced via the Plan.
- Incorporate NSW Government commitments made under the GAB Coordinating Committee Strategic Management Plan.
- Integrate any finalised policy positions developed through the reasonable use guideline for Basic Landholder Rights (stock and domestic usage).

Suggested actions to be considered in the development of the new plan are as follows:

- DoI-Water should consider developing a guidance document on Aboriginal cultural and Aboriginal community licences to support Aboriginal communities and DoI - Water staff with licencing applications, approvals and regulation.

2 Role of the Natural Resource Commission and recommendation

Water sharing plans are statutory instruments under the *Water Management Act 2000* (hereafter referred to as the Act). They prescribe how water is managed to achieve sustainable water management that supports economic, social, cultural and environmental outcomes. They are designed to provide certainty for water users over the life of the plan – typically a period of ten years, unless they are extended.

The Natural Resources Commission (the Commission) has a role under Section 43A of the Act to review water sharing plans that are approaching expiry and provide a report to the Minister on:

- the extent that water sharing provisions of the plan have materially contributed towards achievement of the State priorities for Local Land Services that relate to natural resource management
- whether changes to plan provisions are warranted.

In conducting this review, the Commission is to call for and consider public submissions, and have regard to any other relevant State-wide and regional government policies or agreements that apply to the catchment management area. Depending on its review findings, the Commission may recommend extension or replacement with a new water sharing plan.

This GAB Groundwater Plan is due to expire on 1 July 2018.

2.1 Review approach

2.1.1 Scope

The Commission sought to understand how the provisions of the GAB Groundwater Plan have contributed to State priorities for Local Land Services that relate to natural resource management, specifically the following goals from the Local Land Services State Strategic Plan:

- Biosecure, profitable, productive and sustainable primary industries
- Resilient, self-reliant and prepared local communities
- Healthy, diverse and connected environments.

The Commission identified and examined water sharing provisions of particular relevance to these goals. For example, the Commission considered the role of planned environmental water provisions in providing healthy, diverse and connected environments, and provisions that support productive and sustainable primary industries.

2.1.2 Available evidence

The Commission's review was informed by:

- **Submissions** – the Commission called for submissions via letters to key stakeholders identified by DoI –Water and WaterNSW; a public call for submissions in local newspapers including The Land, North West Magazine, Western Magazine and Barrier Truth Daily; and on the 'Have Your Say' NSW Government website. Stakeholders were asked to respond to eight questions to assess the contribution of the Plan to State priorities for Local Land Services (see Appendix A). Six submissions were received.

- **Targeted consultation** – with government agencies, community and industry organisations.
- **Document review** – the Commission obtained both publically available information and unpublished reports from water management agencies and research agencies including DoI – Water, CSIRO, Department of the Environment and Energy, and the Great Artesian Basin Coordinating Committee. A full list of documents reviewed by the Commission are detailed in Appendix B.
- **Technical advice –** from consultants to provide expert analysis on Plan provisions and opportunities for improvement.

2.2 Recommendation to the Minister

The Commission recommends that the *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008* be replaced with a new management plan that takes into consideration the specific revisions outlined in Table 1. These revisions will contribute to:

- improved clarity of Plan language to ensure that current over entitlement in the recharge sources is transparent to users
- enhancement of the identification and protection of Aboriginal cultural values
- use of best available current knowledge through updating the calculations and assumptions underlying the Plan.

In addition to recommendations related specifically to remaking of the Plan, the Commission suggests that the Minister consider merging the GAB Groundwater Plan with the GAB Shallow groundwater plan.

Table 1: Recommendations

1. The new plan should establish revised sustainable pressure estimate equivalents, planned environmental water provisions and long-term average annual extraction limits to recognise: ▪ improved knowledge of annual recharge and flux in artesian groundwater ▪ data on water use efficiencies made through the Cap and Pipe the Bores program ▪ data from ongoing projects that will improve understanding of GAB artesian pressure ▪ a need for greater clarity and transparency of total extraction limits ▪ apparent errors in the description of the calculation for planned environmental water for the artesian groundwater sources ▪ impacts of climate change in estimates of recharge to facilitate adaptive management of GAB recharge groundwater sources.
2. The Plan should be revised to transparently indicate the current entitlement for water available for allocation to: ▪ provide clarity for water users that 1 share does not equate to 1ML of licensed entitlement for aquifer access licences. ▪ include provisions to allow for updating of licensed entitlement within a groundwater source when appropriate (e.g. due to cancellation and suspension of licences, controlled allocations and improved knowledge of water sources.)

3. DoI – Water should consider the adequacy of the current extraction limit compliance trigger for maintaining sustainable extraction in the event of significant short-term activation of sleeper licence entitlement, and if appropriate amend the trigger in the new Plan.

4. To improve identification and protection of groundwater dependent ecosystems in the new Plan DoI – Water should:

- Complete the survey of artesian springs to ground-truth and nominate groundwater dependent ecosystems to be protected within the new Plan.
- Establish appropriate set back distance of water supply works based on best available scientific evidence to avoid impacting high priority artesian springs or unduly restricting works approvals.
- Update Plan provisions to establish an approach to rehabilitation of water supply works that pre-date set-back distances under the GAB Groundwater Plan to adequately protect high priority artesian springs. It is noted that this should be carried out following completion of the survey.

5. To better reflect system take and ensure ongoing sustainability of extraction in the new plan DoI-Water should:

- Apply the best available methodology to estimate stock and domestic requirements under basic landholder rights. At a minimum this should incorporate climate data and availability of non-groundwater sources to improve reliability of stock and domestic requirement estimates.
- Align provisions for local utility access licences with other groundwater water sharing plans to allow for ongoing town water supply.
- Provide greater transparency around water taken through aquifer interference by implementing measures to allow for identification of water allocated for aquifer interference separate from water extracted out of the system and removing aquifer interference access licences as a licence category in the Plan.
- Consider the extent to which Division 6 (Controlled activities and aquifer interference activities) of the Act should be applied in the new Plan.

6. In developing the new plan, DoI-Water should consult with Aboriginal communities to identify groundwater sites of Aboriginal spiritual, social and customary value, and clarify the objectives and performance indicators in relation to cultural values. The new Plan should include provisions that identify (or nominate a database location) for cultural values within the GAB Groundwater Plan area.

7. Administrative boundaries should be updated by DoI – Water in the new Plan to:

- Redefine the boundaries of the Warrego groundwater source as defined in Schedule 2 based on latest available knowledge.
- Re-classify registered bores impacted by the change in the Warrego groundwater source boundaries and notify affected licence holders.
- Merge the NSW GAB Shallow and GAB Groundwater Plan in recognition of the constraints imposed by continuing to separate the Plans at the currently defined boundary of 60m, and to assist in groundwater management across administrative boundaries.

8. To improve overall clarity of the new Plan DoI – Water should:

- implement a simplified template and consistent terminology
- clarify aspects of the Plan that create confusion based on input from stakeholders, including extraction limits, Plan boundaries and links to other water sharing plans.
- update the objectives, strategies and performance indicators in the new plan. These should be logically linked and specific to enable the monitoring and delivery of plan outcomes.

9. In developing the new plan, DoI- Water should complete current efforts to:

- Apply metering policies developed under the Water Reform Action Plan to improve assessment of impacts and available water determinations enforced via the Plan.
- Incorporate NSW Government commitments made under the GAB Coordinating Committee Strategic Management Plan.
- Integrate any finalised policy positions developed through the reasonable use guideline for Basic Landholder Rights (stock and domestic usage).

3 The Great Artesian Basin Plan area

3.1 Overview of the Great Artesian Basin (GAB)

The Great Artesian Basin (hereafter referred to as the GAB) is one of the most important water resources in Australia and underlies 1.7 million square kilometres or approximately 22% of the continent. [2] A total of 207,592 square kilometres (or approximately 12%) falls within the NSW State boundaries.

The NSW GAB is part of the Surat and Central Eromanga geological basins (see Figure 1). These geological basins were formed 65–205 million years ago, during the Jurassic and Cretaceous periods.

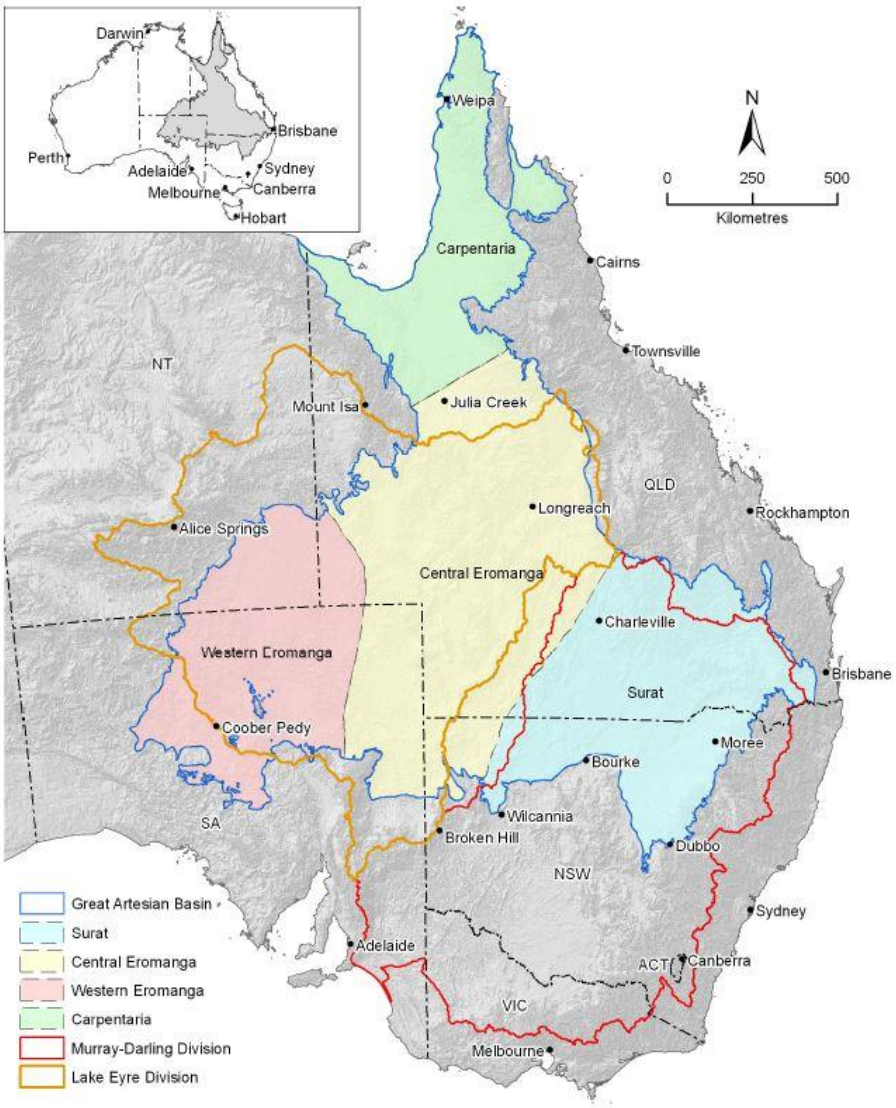

Figure 1: Geographic extent of the GAB with selected overlying surface water drainage divisions[3]

[2] Great Artesian Basin Coordinating Committee (2009). Great Artesian Basin Strategic Management Plan: Progress and Achievements to 2008.

[3] Smerdon, B.D., Ransley, T. R., Radke, B. M. and Kellet, J. R. (2012). Water Resource assessment for the Great Artesian Basin. A report to the Austrlaian Government from the CSIRO Great Artesian Basin Water Resource Assessment. CSIRO Water for a Healthy Country Flagship, Australia.

The NSW GAB is comprised of alternating layers of water-bearing (permeable / aquifer) sandstones, confined by non-water-bearing (impermeable / aquitards) fluvial and marine siltstones, mudstones and shale. The aquitards confine water held in the aquifer layers under pressurisation, which for the artesian groundwater sources in the NSW GAB, will allow water to flow naturally to the surface when a bore is drilled in to the permeable layer.[4]

It is estimated the entire GAB holds more than 65 million gigalitres and due to slow horizontal movement of water (0.1–5 metres / year), water discharging has been aged in excess of 2 million years old. [5] In NSW, the depth of the GAB can extend to 1,300m and reach temperatures up to 80°C. [6]

3.2 The GAB Groundwater Plan Area

The NSW GAB Groundwater Plan applies to five administrative groundwater sources:

- the Eastern Recharge Groundwater source
- the Southern Recharge Groundwater source
- the Surat Groundwater source
- the Warrego Groundwater source
- the Central Groundwater source.

The boundaries of the NSW groundwater source areas are provided in Figure 2Table 2. Additional clauses to highlight the boundaries of the water sources applicable to the Plan are outlined in Table 2.

Table 2: Additional criteria for water source boundaries outlined in the NSW GAB Groundwater Plan

Groundwater source	Included in GAB Groundwater Plan	Excluded in GAB Groundwater Plan
Eastern / Southern Recharge	Water contained in rocks of Cretaceous, Jurassic and Tertiary age All alluvial sediments	Excluded alluvial areas as highlighted in Figure 2
Surat / Warrego / Central	Water contained in rocks of Cretaceous and Jurassic age below 60m (from ground level)	Water in rocks above a depth of 60m (from ground level) Excluded alluvial areas as highlighted in Figure 2

The GAB Groundwater Plan also excludes any water contained in the following legislated water sharing plans:

- *Water Sharing Plan for the Lower Gwydir Groundwater Source 2003*
- *Water Sharing Plan for the Lower Macquarie Groundwater Sources 2003*

[4] It is noted that not all bores in the artesian groundwater sources continue to flow naturally to the surface due to pressure impacts. A study is currently being undertaken by the Department to quantify artesian bores (See Section 5.1).
[5] Great Artesian Basin Coordinating Committee (2009). Great Artesian Basin Strategic Management Plan: Progress and Achievements to 2008.
[6] Smerdon et al. (2012).

- *Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003*
- *Water Sharing Plan for the Castlereagh below Binnaway Unregulated and Alluvial Water Sources 2011*
- *Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources 2011*
- *Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011*
- *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Source 2011*

The area covered by each of the GAB groundwater sources is extensive and outlined in Table 3. There is a differential between the total land area overlying the GAB and the area identified in the Plan, as not all GAB geological areas are included in the GAB Groundwater Plan.

Table 3: Area of the NSW GAB groundwater sources[7]

Groundwater source	Area (km^2)
Eastern Recharge	6,131
Southern Recharge	23,602
Surat	73,833
Warrego	35,821
Central	64,613
Total	**204,000**

[7] DPI Water (2015). NSW GAB groundwater sources – groundwater status report. Draft, unpublished.

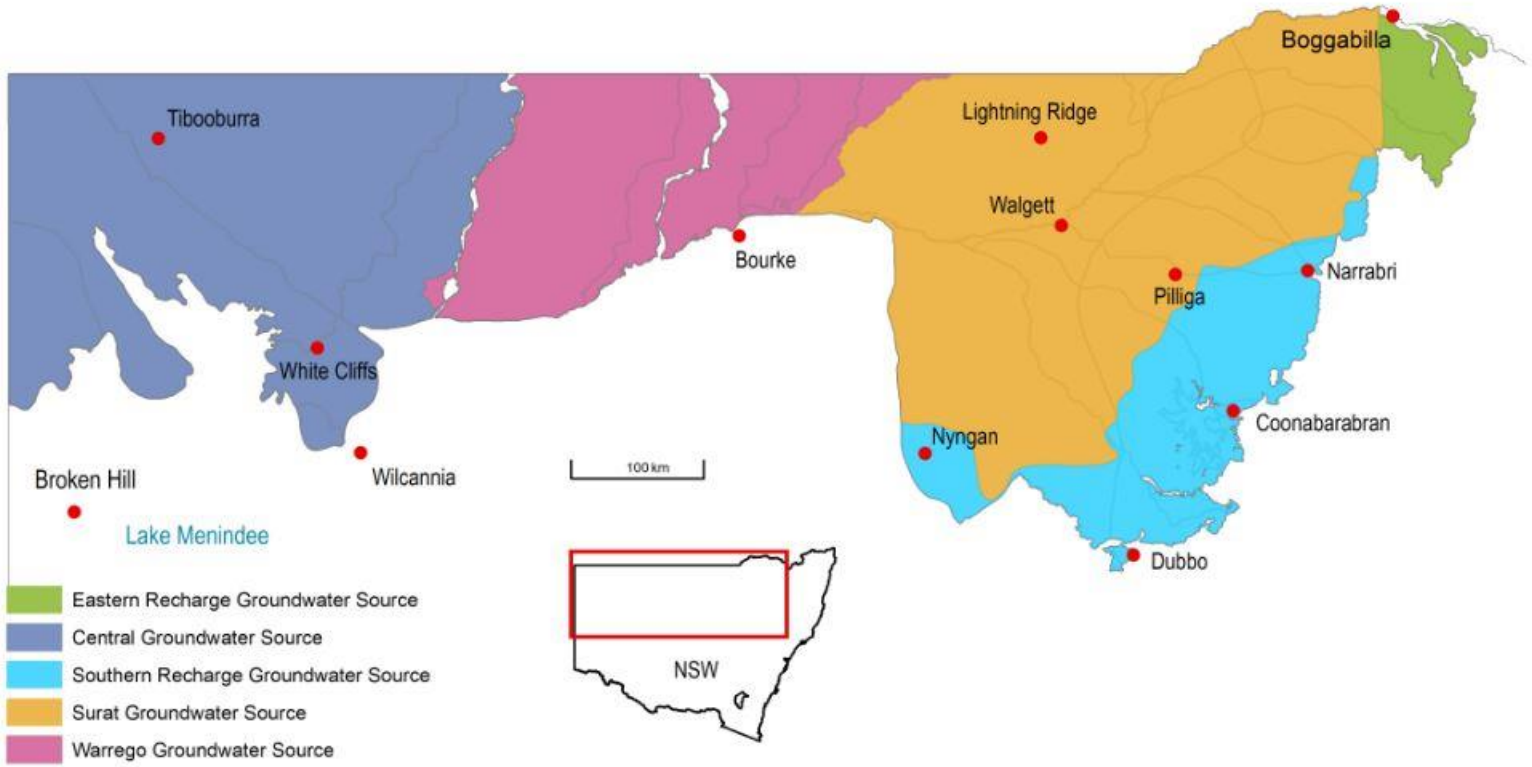

Figure 2: Overview of the NSW GAB groundwater sources 2011[8]

[8] *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008*

3.3 Overview of economic conditions, land and water use

Use of the NSW GAB varies according to the quality of the water being extracted from the aquifer. Water in the GAB is utilised in NSW for:

- pastoral e.g. water supply for stock
- domestic water supply
- town water supply
- industrial water use e.g. mining
- irrigation
- tourism e.g. spa bath industry

The economic value of NSW industries reliant on GAB water sources is estimated at $1.8 billion per year.[9] A breakdown of economic value by industry sectors dependent on GAB water resources is provided in Table 4. The economic value of industries within the GAB Groundwater Plan area that are reliant on non-GAB water sources (e.g. rainfall, surface water resources) are not accounted for in Table 4.

Table 4: Estimated economic value of sectors dependent on GAB water resources[10]

Sector	Value of sector ($ million per year)
Stock	1,095
Mining	568
Coal Seam Gas	8
Irrigated agriculture	30*
Urban water	7
Tourism expenditure	101
Total value of output	**1,809**

* It is noted that the value of irrigated agriculture occurring in the GAB in these estimates is significantly inflated. The total value of irrigated agricultural production was calculated according to the total volume of aquifer access entitlement on issue for each water source as opposed to actual extraction volumes used for the purpose of irrigation within the GAB Groundwater Plan area.

At commencement of the GAB Groundwater Plan in 2008, pastoral industries accounted for approximately 85% of total GAB water use in the Plan area. However, it is anticipated that this percentage will have decreased as a consequence of the Cap and Pipe the Bores program, which improved water efficiency of stock and domestic users. See Section 3.5 for further discussion of this program.[11]

The majority of water extracted from the GAB is unsuitable for irrigation of many crops and will degrade soil condition due to high levels of sodium and/or salinity in groundwater.

[9] Frontier Economics (2016). Economic output of groundwater dependent sectors in the Great Artesian Basin. A report commissioned by the Australian Government and Great Artesian basin jurisdictions based on advice from the Great Artesian Basin Coordinating Committee.
[10] Ibid. See footnote 9.
[11] Department of Water and Energy (2009). Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources – Background Document.

Irrigation predominantly occurs in the Eastern Recharge groundwater source in the North Star / Croppa Creek region. The Southern Recharge groundwater source supports moderate irrigation enterprises in Narromine, Collie, Gilgandra and Narrabri. Some mixing of surface water and GAB groundwater for irrigated agricultural production is known to occur to the west of Narrabri where entitlement overlies the Surat groundwater source.[12] The activation and use of entitlement within the Surat groundwater source is dependent on seasonal conditions and the associated availability of surface water resources and rainfall. Additional constraints for pastoral use occur along the boundary between the Warrego and Central groundwater sources due to fluoride levels in excess of 10 mg/L.[13] A summary of some key characteristics for each groundwater source is outlined in Appendix D.

3.3.1 Environmental values

Environmental water provisions within the GAB Groundwater Plan are principally in place for the management of springs (referred to as groundwater dependent ecosystems within the Plan). Springs fall in to two categories:

- Recharge springs – supplied from groundwater from an aquifer or aquifers that are unconfined in the spring region, and occur in the recharge areas of the GAB.[14]
- Discharge springs – fed by groundwater moving upwards under artesian pressure through thin confining beds or along faults.

Springs are a rare habitat and their importance within the Australian landscape has been recognised in their listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Artesian springs at the southern margins of the GAB in north-western NSW are listed as endangered under the NSW *Threatened Species Conservation Act 1995* as *Artesian springs ecological community*.

As highlighted in Figure 3, spring complexes in NSW are clustered in to the Bourke and Bogan River super group, with the majority of these overlying the Warrego groundwater source.

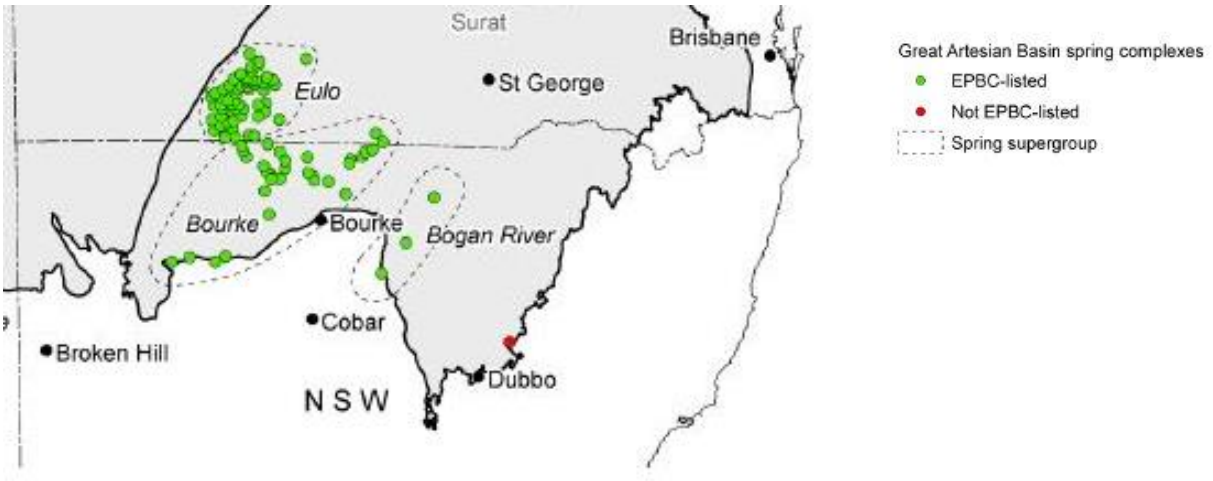

Figure 3: Springs of the Great Artesian Basin[15]

[12] Iverach et al. (2017) indicated that mixing of alluvial and GAB groundwater sources is reported to be as high as 70% generating questions around how to manage groundwater inter-source exchange in water sharing plans.
[13] DPI Water (2015). NSW GAB groundwater sources – groundwater status report. Draft, unpublished.
[14] Field studies to date have not identified and recharge springs in the NSW GAB Groundwater Plan area
[15] Smerdon, B.D., Ransley, T. R., Radke, B. M. and Kellet, J. R. (2012). Water Resource assessment for the Great Artesian Basin. A report to the Austrlaian Government from the CSIRO Great Artesian Basin Water Resource Assessment. CSIRO Water for a Healthy Country Flagship, Australia.

It is estimated almost 80 plant and animal species are endemic to the GAB discharge spring wetlands.[16] While this number represents the endemic species across the entire GAB, Peery Lake is recognised as the most biologically significant springs complex within the Bourke supergroup.[17] Peery Springs is protected as part of the Paroo-Darling National Park and is the only known springs complex located on a lakebed.[18] Peery Springs are characterised by mounds of mud and evaporate deposits (mineral sediments resulting from evaporation).

3.3.2 Aboriginal cultural values

Aboriginal artefacts are abundant at nearly all spring areas west of Bourke, with rich surface archaeology noted on groundwater scalds surrounding Coonbilly, Goonery, Hawkes, Kullyna, lake Eliza and Native Dog springs. Many of the springs have indigenous names Yantaboollaboola (Yantabulla), Yanaranah (Youngerina), Goonarah (Goonery); however, in many cases the original pronunciation and stories attached to springs have been lost.

Peery Lake is of high cultural significance and features in stories of Kuluwirru Dreaming that describes the wetting and drying cycles of the lake. The Paroo-Darling National Park also supports a number of plants of Aboriginal significance that are of traditional food or medicinal value and are documented in oral history including wild banana vine (*Marsdenia australis*) and the yam known as *ngarnti.* Archaeological research surrounding the Peery springs has identified a number of important artefacts including middens, hearths, stone tools, rock engravings, art sites and stone arrangements.

The Aboriginal dreaming story of Cuddie springs has been documented in the historical record and Coorigul spring is identified as the start of a dreaming track that follows the Bogan River. The dreamtime story has been painted as a mural on Opal Street at Lightning Ridge (Figure 4).

Figure 4: Coorigul spring dreaming story mural, Lightning Ridge[19]

[16] Department of Environment and Energy (2018). The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin in Community and Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 26 April 2018.
[17] Commonwealth of Australia (2014). Ecological and hydrogeological survey of the Great Artesian Basin springs – Springsure, Eulo, Bourke and Bogan River supergroups. Volume 1: history, ecology and hydrogeology, knowledge report, prepared by UniQuest for the Department of the Environment.
[18] Office of Environment and Heritage (2012). Paroo-Darling National Park and State Conservation Area. Plan of Management.
[19] Tripmondo – Discover Lightning Ridge. Photo credit Louise Docker. Available at https://www.tripmondo.com/australia/new-south-wales/walgett/lightning-ridge/

3.3.3 European heritage values

Early exploration of inland Australia and pastoral settlement was reliant on water provided by springs. The crucial water supply provided by springs during early European settlement hinted at the GAB groundwater source and deeper bore drilling commenced in the 1880s. By 1960, an estimated 18,000 bores had been sunk across the entire GAB. However, extensive development resulted in a significant loss of pressure in the aquifer.

By the mid-1990's there was an estimated discharge of 1,560 megalitres per day. The high levels of discharge over more than one hundred years resulted in approximately a third of the original artesian bores ceasing to flow and extinction of approximately 1,000 springs.[20] Significant changes in flow rates resulted in the abandonment of early pastoral leases and surrounding settlements. Some of these pastoral buildings (e.g. homesteads, shearing sheds, shearers quarters, stone tanks and mulga-post fences) are being maintained through National Park management plans to ensure a historical record of early pastoral history in inland Australia.

3.4 Water management within the GAB Groundwater Plan

The Plan establishes different approaches to groundwater management based on the hydrogeology of the water sources. The Eastern and Southern Recharge water sources are managed according to system recharge. The Warrego, Surat and Central water sources (hereafter collectively referred to as artesian groundwater sources) are managed to maintain artesian pressure. Management of long-term average annual extraction limit and available water determinations is discussed in Section 5.

The geological ages of the GAB artesian groundwater sources[21] provide an indication of the timeframes for recharge to the artesian system. As a consequence of these long time frames, the GAB artesian sources are managed as a finite resource with extraction, adopting a precautionary approach.

3.4.1 Non-licensed extraction

Consistent with the Act, basic landholder rights apply for:

- domestic (household) use and to water stock; and
- native title rights.

3.4.2 Licensed extraction

Licence categories available to access GAB groundwater include:

- aquifer access licences (required for irrigation, spa bath industry take, mining and coal seam gas extraction; Aboriginal cultural and Aboriginal community purposes)
- local water utility access licences
- domestic and stock access licences
- aquifer (interference) access licences
- domestic and stock (conveyance) access licences
- supplementary water access licences.

[20] Great Artesian Basin Coordinating Committee (2009). Great Artesian Basin Strategic Management Plan: Progress and Achievements to 2008.
[21] GAB geological basins range in age from 65–205 million years ago with water discharging from the GAB aged in excess of 2 million years old (Section 3.1).

Provisions to issue domestic and stock (conveyance) access licences (Section 22) and supplementary water access licences (Section 26 and 27) have not been enacted under the GAB Groundwater Plan. This is discussed further in Section 5.2.

3.4.3 Water trade

Rules governing water trade

Provisions within the Plan prohibit interstate trade (Section 46) and trade between groundwater sources (Section 43 (2)). Allocation trade is permitted between artesian groundwater sources; however, allocation trade between recharge and artesian groundwater sources is prohibited (Section 47). This is due to the difference in management approaches and accounting systems adopted in the recharge and artesian groundwater sources.

Trades are not permitted where, as a result of the trade (considering other extraction within the area including basic landholder rights) there would be resulting adverse local impacts (Section 43(2)). Allocation trade in the Eastern Recharge Groundwater Source was prohibited until 1 July 2013.

Entitlement trade

A small number of entitlement trades have occurred in the GAB Groundwater Plan area within the recharge groundwater sources. Since 2012, there has been a total of four trades in each Recharge groundwater source. A total of 1,056 shares have been traded in the Southern Recharge groundwater source and 2,172 shares have been traded in the Eastern Recharge groundwater source.[22]

Allocation trade

Limited allocation trade has occurred in the recharge groundwater sources and the Surat groundwater source. In 2010–11 two allocation trades equating to a volume of 169 ML were traded in the Surat groundwater source.[23] A total of 15 allocation trades have been made across the recharge groundwater sources, at a total volume traded of 4,530 ML.[24]

Trade is allowed under water sharing plans to encourage economically efficient use of the water sources. The limited trade in the current system is likely due to current availability of water within most of the groundwater sources. However, demand is approaching the Plan allocation limits in the Eastern Recharge source and trade is likely to become more important in this area in the future. Further discussion in regards to the need for transparency of entitlement and allocation to ensure proper pricing of water is discussed further in Section 5.2.

3.5 Cross-jurisdictional arrangements applicable to the GAB Groundwater Plan

A cross-jurisdictional approach is taken to the management of the GAB in recognition that:

- the groundwater resource covers multiple states and territories including the Northern Territory, New South Wales, Queensland and South Australia

[22] Aither (2018). Water trade analysis for water sharing plan reviews. Analysis of water trade for the Bellinger River, Border Rivers and Great Artesian Basin water sharing plans.
[23] Data from the NSW Water Register. Accessed 23 May 2018.
[24] Ibid. See footnote 23.

- the flow patterns and recharge across the GAB, whereby flow moves from Queensland into NSW and across into South Australia.

There are two key committees / organisations that facilitate cross-jurisdictional management of water resource management – the GAB Coordinating Committee and the GAB Senior Officers Group.

The GAB Coordinating Committee was established in 2004 and superseded the GAB Consultative Council. The primary role of the GAB Coordinating Committee is to provide advice to Australian, State and Territory Ministers on community concerns regarding efficient, effective and sustainable whole-of-Basin resource management, and to coordinate activity between stakeholders.[25] The Committee has the following roles:

- champions the GAB Strategic Management Plan
- provides independent advice on key issues impacting the Basin
- provides overall reporting on the GAB resource including current risks to the Basin and State-based approaches to GAB groundwater management
- monitors progress of the GAB Sustainability Initiative (referred to as the Cap and Pipe the Bores Program in NSW - see Box 1)
- identifies research needs that will assist in the delivery of GAB groundwater management approaches.

Box 1: Details of the Cap and Pipe the Bores program

Over 8,500 groundwater bores have been drilled in NSW since commencement of groundwater exploration. Many of these historical bores were allowed to flow unrestricted, which has resulted in excessive extraction, wastage and loss of bore pressure. It is estimated that as much as 95% of water that comes from a bore can be lost due to seepage and evaporation from bore drains.

The NSW Cap and Pipe the Bores program was introduced in 1993 and was rolled into the GAB Sustainability Initiative in 1999. Under the GAB Sustainability Initiative, the Commonwealth Government in conjunction with state government and landholders invested in reconditioning and replacement of unrestricted flowing artesian bores and installation of piping to replace bore drain structures.

To date the following has been achieved under the NSW Cap and Pipe the Bores program:

- 397 bores controlled
- 9,949 km of bore drains decommissioned
- 17,785 km of efficient pipe drains installed
- 77,881 ML of water efficiencies gained each year.

Over 70% of the bores controlled to date have been located in the Surat groundwater source. Monitoring bores have recorded signs of pressure recovery. It is recognised that pressures recorded prior to the development of the GAB will not be achieved through the Cap and Pipe the Bores program, with the target instead the achievement of a new stabilised pressure.

Representatives on the committee seek to provide feedback from major GAB stakeholder groups including community groups, Aboriginal communities, industrial users (gas, mining

[25] GAB Coordinating Committee (2016). Annual Report 2015–2016.

and agricultural), and environmental sectors. The GAB Coordinating Committee also has agency representatives from GAB states that seek to provide technical support and advice. In the case of NSW, the community representative is the active Chair of the NSW Great Artesian Basin Advisory Group. The GAB Coordinating Committee reports to the GAB Senior Officers Group.

The GAB Senior Officers Group is comprised of senior water management staff across jurisdictions from State Water Planning agencies. The role and functions of the GAB Senior Officers Group is currently unclear.

Stakeholder feedback received during the consultation process indicated some concerns regarding the cross-jurisdictional management of the GAB. The Commission's view is that the current governance framework to consider GAB cross-jurisdictional matters is appropriate. Greater transparency of the current governance frameworks in place to facilitate cross-jurisdictional management of the GAB may alleviate stakeholder concerns.

3.6 Consideration of coal seam gas development in the GAB Groundwater Plan

Stakeholders expressed concerns regarding potential impacts of coal seam gas (CSG) development, specifically those associated with the Narrabri Gas Project, and how this may impact the GAB Groundwater Plan. Concerns raised included:

- questions about the baseline data available and ability to identify impacts in a sufficient time period to respond to them
- potential impacts from CSG activities in Queensland
- protection of groundwater dependent ecosystems
- management of potential long-term impacts from CSG
- potential impacts on water quality
- requirements for receiving an aquifer interference approval.

The Commission has reviewed stakeholder concerns as they relate to the GAB Groundwater Plan and believes that those that relate specifically to the Plan will be appropriately addressed through implementation of the recommendations made in this report. Many of these issues are handled predominantly outside the Plan, through the Water Management Planning requirements of the Department of Planning and Environment. Relevant suggested changes to be made to the GAB Groundwater Plan include:

- the revision of the sustainable pressure estimate equivalent and long-term average annual extraction limit to manage extraction within the GAB groundwater sources (Section 5.1)
- updates to groundwater dependent ecosystems identified in Schedule 4 of the Plan (Section 5.3) and appropriate set-back distances
- greater transparency in water taken through aquifer interference activities, for both coal seam gas extraction activities (as referred to in this Section) and other activities designated in the Act (Section 5.4.3).

4 Contribution to LLS state priorities

In undertaking the review the Commission has assessed evidence in regards to the extent that the Plan is contributing to Local Land Services state priorities (as outlined in Section 2.1). There is a general alignment between the three goals identified as Local Land state priorities and the objectives of the Plan (see Appendix C). A discussion of the performance against social, economic and environmental indicators as established in the Local Land Services state priorities and GAB Groundwater Plan objectives is detailed below.

4.1 Social indicators

Objectives and performance indicators are outlined in the GAB Groundwater Plan that seek to maintain cultural and heritage values within the Plan area. Specific provisions in the GAB Groundwater Plan have been established to provide groundwater access licences for Aboriginal cultural and community purposes. However, to date cultural and heritage values within the Plan have not been identified and no access licences have been issued for Aboriginal cultural and Aboriginal community purposes. This is further discussed in Section 5.5.

During the submission and consultation process, stakeholders identified that the GAB Groundwater Plan was confusing for users. Particular issues identified included:

- no clear rationale for the separation of the GAB Shallow and GAB Groundwater Plan
- lack of clarity around extraction limits identified in the GAB Groundwater Plan
- linkages within the GAB Groundwater Plan that defer to the Act
- confusing terminology

The Commission has identified recommendations to improve communication and discussion of the Plan objectives, strategies and performance indicators (Section 5.7); extraction limits (Section 5.1); Plan boundaries (Section 5.6) and Plan clarity (Section 5.7).

Local utility access licences continue to supply water for rural towns and to date no issues with town water supply have been reported.

4.2 Economic indicators

The Plan continues to support productive industries, particularly pastoral industries in inland NSW, where the supply of surface water resources is otherwise limited. This is supported by stakeholder feedback that has in general provided positive feedback, particularly in relation to pressure recovery in the Basin, where the Cap and Pipe the Bores program (Box 1) has resulted in an improvement in artesian bore flow rates. Improvements to calculation of basic landholder rights will enable improved security for the ongoing supply of water for stock and domestic purposes (Section 5.4.1).

The Eastern Recharge groundwater source is over-entitled relative to the long-term annual net recharge. Demand within the Eastern Recharge groundwater source is increasing. As extractive industries increasingly compete for the use of groundwater resources, there will be a need for greater transparency to clearly communicate with stakeholders to allow them to manage risk of reduced groundwater allocation. A review of the compliance trigger may also be warranted to ensure management of groundwater allocation within long-term average annual extraction limits (Section 5.2). Ongoing improvement to system monitoring will ensure compliance with extraction limits and is further discussed in Section 5.8.1.

4.3 Environmental indicators

There has been reported improvement in artesian pressures following the Cap and Pipe the Bores program (Box 1). The program has reduced significant wastage of artesian groundwater and reduced pest and weed pressure through management of artesian bores. There is anecdotal evidence to suggest that where artesian bores have been managed, flows from artesian springs are occurring.

There is a need to improve current identification of groundwater dependent ecosystems (high priority artesian springs) within the Plan. This will ensure their ongoing protection as significant ecological communities with endemic flora and fauna. Completion of surveys of high priority artesian springs and the establishment of set-back distances that are based on best available scientific evidence will provide the framework for their ongoing protection. A comprehensive discussion of groundwater dependent ecosystems and their protection in the Plan is provided in Section 5.3.

5 Key issues

5.1 Clarity of GAB Groundwater Plan total extraction limit

Lack of clarity around calculation of limits

A clear total annual extraction limit is critical for providing transparency to water users in regards to the water available under their entitlement. The current Plan has clauses that specify how the annual extraction limit is to be calculated for recharge and artesian sources and mechanisms available to adjust the limits.

Annual extraction is specified in the Plan as the 'long-term average annual extraction limit'. The calculations for the annual extraction limit refer to clauses that are spread throughout the Plan. Most of those clauses do not provide specific numeric values. Where there is no numeric value specified in the Plan, there is little transparency around how the values are derived by the Department. The fact that the Plan does not identify a clear value for the long-term average annual extraction limit for any of the GAB groundwater sources creates confusion and uncertainty for users.

There also appears to be potential errors in the language of the provisions for how the planned environmental water value for the artesian systems is calculated. This issue was identified in the DoI – Water audit, which stated that current wording of Plan provisions erroneously results in a negative number for the long-term average annual extraction limit.[26] The calculation needs to be re-evaluated and the wording in the new plan updated such that the calculation works as intended.

New data that will impact sustainable limits

In addition to a lack of clarity within the Plan, there is significant new information available since the Plan was developed, which indicates that the settings in the Plan should be adjusted. While provisions have been included to allow the extraction limits to be varied across groundwater sources[27] based on certain new information, no changes have been made over the life of the Plan.

The extraction limit for the artesian groundwater sources is based upon a "sustainable pressure estimated equivalent". The extraction allowed is meant to ensure that the desired pressure is maintained in the system. The Plan (Section 15(2)) allows for the extraction limit to be varied based on water use efficiencies recorded under the Cap and Pipe the Bores program. While the data necessary to make these adjustments has been recorded, the extraction limit within the GAB Groundwater Plan has not been revised. This data should be incorporated as appropriate into a revised sustainable pressure equivalent estimates within the new plan.

The Department should also determine whether there is expected to be significant additional water use efficiencies after the start of the new plan from the Cap and Pipe the Bores program. If so, then new provisions to address these water use efficiencies and how they will be allocated will be needed. The current Plan allows for 30% of the water use efficiencies acquired through implementation of the Cap and Pipe the Bores program to be distributed via licences through "controlled allocation". One such allocation has occurred in 2009. The impact of that allocation

[26] Department of Industry – Water (unpublished). Draft audit of implementation – Inland groundwater water sharing plan audit report cards. Prepared for the period between 1 July 2008 and 30 June 2013. Department of Primary Industries, Office of Water.
[27] (Section 15(3))

should be reflected in the total entitlements and sustainable pressure equivalent under the new plan. The Department should also determine whether the allocation of 30% of water use efficiencies for controlled allocation remains appropriate and if not, adjust the new plan as necessary.

Since the establishment of the GAB Groundwater Plan in 2008, substantial research has been undertaken to improve understanding of annual recharge estimates for the recharge groundwater sources and the flux in artesian groundwater sources. Evidence collected by the DoI - Water highlights the pressure recovery that has occurred in artesian groundwater sources to date.[28] This has been supported by stakeholder feedback, indicating an increase in artesian bore flow rates following the implementation of the Cap and Pipe the Bores program.

Research projects currently being undertaken by the DoI – Water will further assist in establishing the data to inform sustainable pressure equivalents. It will also identify where Cap and Pipe the Bores water use efficiencies figures might need to be adjusted due to the fact that as a result of increased pressure some 'cease to flow' bores are recovering. Details of these research projects are provided in Table 5.

Multiple research studies have also been carried out to quantify the impacts to recharge resulting from climate change including associated changes in rainfall patterns.[29] The impacts of climate change should be considered in the adjustment of the long-term average annual extraction limit for the duration of the new GAB Plan. Consideration of impacts to recharge volumes (including the anticipated timeframe for these changes) will facilitate timely and effective management of GAB recharge groundwater sources.

Table 5: DoI – Water projects underway to improve knowledge of GAB artesian groundwater sources

Details of DoI – Water project currently underway	Contribution to increased knowledge of GAB artesian groundwater sources
Project to identify bores that have recommenced flowing following the Cap and Pipe the Bores program (GAB sustainability initiative).	Project will assess the level of artesian pressure recovery that has occurred following the Cap and Pipe the Bores program (including the four stages of GAB sustainability initiative). DoI – Water has received anecdotal advice that bores that were previously 'cease to flow' have now started to flow as a result of the Cap and Pipe the Bores program. The project will seek to assess bore head condition, flow status, pressure and also log any bores on properties not currently on the Departmental registers.
Project to develop future pressure maps for the NSW groundwater GAB	Project will develop pressure recovery maps for the NSW groundwater GAB for 1990, 2018 and 2038. This modelling research will assist in the formulation of the sustainable pressure estimate equivalent that is used to manage artesian pressure in the Surat, Warrego and Central groundwater sources.

[28] DPI Water (2015). NSW GAB groundwater sources – groundwater status report. Draft, unpublished.
[29] CSIRO (2008). Water availability in the Murray-Darling Basin – A report from CSIRO to the Australian Government and Smerdon, B.D., Ransley, T. R., Radke, B. M. and Kellet, J. R. (2012). Water Resource assessment for the Great Artesian Basin. A report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment. CSIRO Water for a Healthy Country Flagship, Australia.

Recommendation

1. The new plan should establish revised sustainable pressure estimate equivalents, planned environmental water provisions and long-term average annual extraction limits to recognise:

- improved knowledge of annual recharge and flux in artesian groundwater
- data on water use efficiencies made through the Cap and Pipe the Bores program
- data from ongoing projects that will improve understanding of GAB artesian pressure
- a need for greater clarity and transparency of total extraction limits
- apparent errors in the description of the calculation for planned environmental water for the artesian groundwater sources
- impacts of climate change in estimates of recharge to facilitate adaptive management of GAB recharge groundwater sources.

5.2 Over-entitlement of recharge groundwater sources

Currently the recharge groundwater sources are over-entitled. This may not be apparent to users because currently many of the licences are not being actively used, but are "sleeper licences". There is a risk that a significant number of these could be activated, resulting in a reduction in the allocation against entitlement for all users. This risk is not currently transparent for users. Improved transparency will enable water users to manage their risks and take action, through potential market based mechanisms such as water trade, to limit exposure to a reduction in water allocation. A lack of transparency of this over-entitlement risk results in an uninformed market, where the true value of a groundwater licence may not be realised.

Licensed entitlement across the groundwater sources is issued according to Section 25 of the GAB Groundwater Plan.[30] The current licensed entitlement is provided in Table 6. As highlighted in Table 6 there has been a change in entitlement across the Plan area over the life of the Plan. In some cases these changes have been significant with a 95% reduction in entitlement in the Central groundwater entitlement. DoI – Water indicated that reasons for these shifts in entitlement may occur due to the following reasons:

- cancellation or suspension of licences
- conversion of perpetual licences (issued under the *Water Act 1912*) to volumetric licences following the introduction of the GAB Groundwater Plan
- controlled allocations issued in 2009
- issuing licences where applications were pending at the time of writing of the GAB Groundwater Plan
- improved knowledge that resulted in a change to the nominated groundwater source on the licence.[31]

The current Plan does not have provisions in place to allow for increases in entitlement. This is in contrast to other water sharing plans that enable changes to entitlement on issue for reasons such as those specified above. In recognition that improved knowledge, controlled allocation

[30] Aquifer Access Licences are issued as a share component. Local Water Utility Access Licences and Stock and Domestic Access Licences are annual volumetric entitlements.
[31] DoI – Water, Pers Comm, 17 May 2018.

and cancellation of licences may require changes to entitlement on issue within a water source, insertion of provisions that enable this to occur in specific and appropriate situations should be included in the new Plan. The Department should also take steps to ensure that entitlement is not varied unless allowed within the Plan.

Table 6: Current licensed entitlement on issue in the GAB Groundwater Plan area[32]

Source	Aquifer access licence		Local water utility access licence		Domestic and stock access licence[33]		Total entitlement share		% change on 2008 entitlement share
	No.	Unit shares	No.	Unit shares	No.	Unit shares	(2018)	(2008)[34]	
Eastern recharge	79	34,974	-	-	1	32	35,006	32,000	9
Southern recharge	155	24,739	9	3,066	-	-	27,805	25,000	11
Surat	52	5,502	12	3,418	-	-	8,920	15,100	(41)
Warrego	5	406	3	252	-	-	658	1,600	(59)
Central	9	43	1	25	-	-	68	750	(91)
Total	**300**	**65,664**	**25**	**6,761**	**1**	**32**	**72,457**	**74,450**	

The entitlement shares far exceed the long-term annual recharge for the recharge groundwater sources. A representation of total entitlement share on issue in the recharge groundwater sources versus the current GAB Groundwater Plan long-term average annual extraction limit is provided in Figure 5. It is noted that this represents entitlement share rather than the volume of entitlement extracted within the recharge groundwater sources.

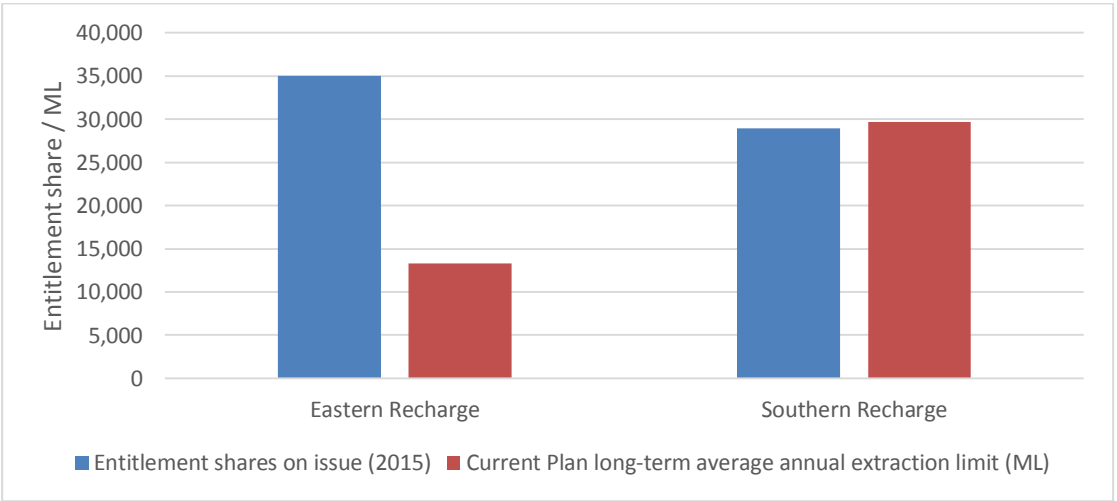

Figure 5: Entitlement share compared to current long-term average annual extraction limit (recharge groundwater sources)

[32] Actual entitlement by groundwater source. Data from the NSW Water Register. Accessed 30 May 2018.
[33] This represents a Stock and Domestic access licence, not a basic landholder right (stock and domestic). The stock and domestic access licence is held by a community group.
[34] Estimate of entitlement by groundwater source at the commencement of the water sharing plan.

In order to manage extraction to the sustainable limits, an available water determination is made for groundwater aquifer access licences at the start of allocation each water year. Extracted groundwater take is metered to allow for yearly adjustment of the available water determination for aquifer access licences. The GAB Groundwater Plan requires that where the five year average extraction rate (actual use – not allocation) exceeds the long term average annual extraction limit by 10% or greater, allocation is adjusted by the amount determined necessary by the Minister to return water extraction to the Plan's extraction limit. Utility and stock and domestic access licences are not subject to an available water determination and receive 1ML per licence share each year. Further, the available water determination takes into account an estimate of stock and domestic use under basic landholder rights, which does not require a licence.

In recent years there has been increasing use of groundwater use in the Eastern Recharge groundwater source (Figure 6). This has resulted in extraction that is approaching, and recently exceeding, the annual extraction limit in the Plan. While not yet meeting the compliance trigger for the adjustment of the extraction limit, extraction will require close monitoring as there is increasing intensity of competing development needs (future oil and gas development versus agriculture).[35]

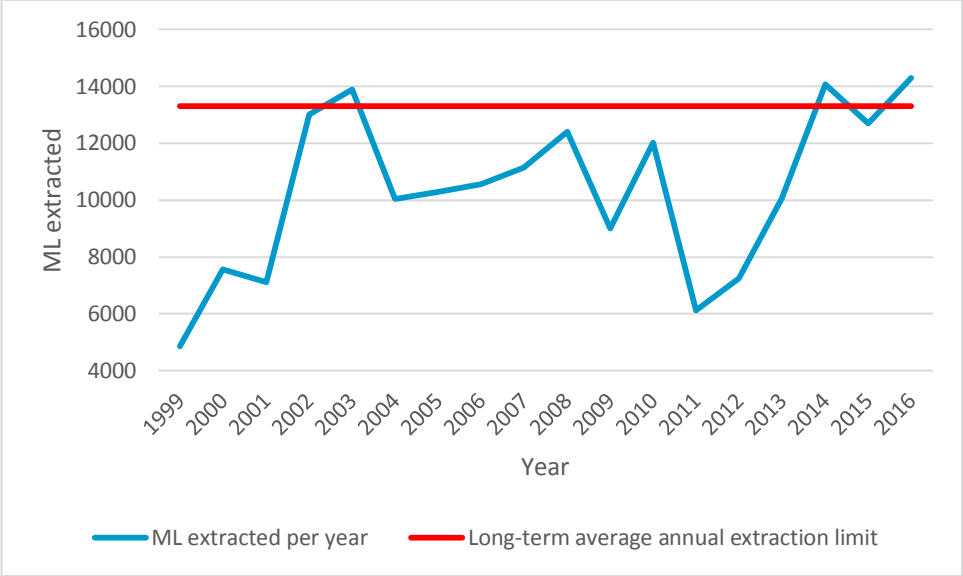

Figure 6: Metered groundwater extraction in the Eastern Recharge groundwater source

An available water determination of 0.8 ML/share was applied in 2008–2009 and 2009–2010 to aquifer access licences in the Eastern Recharge groundwater source. In all other years the available water determination has been set at 1ML/unit share. However, the current approach to managing extraction through historic actual water take generates a future risk for water users within the GAB, as it does not clearly communicate to stakeholders the issues associated with over entitlement of the groundwater source. Despite the availability of resources, such as fact sheets from the Department, to communicate risks to allocation associated with over entitlement of the Eastern Recharge Groundwater Source, transparency of these risks within the new Plan can be improved.[36]

[35] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008

[36] Information on the Eastern Recharge Groundwater Source and implications for over entitlement of the groundwater source is available at https://www.water.nsw.gov.au/__data/assets/pdf_file/0008/549179/GAB-Eastern-Recharge-Groundwater-Source-Fact-Sheet-December-2014.pdf.

The current Plan includes provisions to enable Government to wind back over entitlement of GAB groundwater recharge sources.[37] Under these provisions, a portion of current entitlement was to be converted to supplementary licences. These licences were to be phased out over the life of the Plan, such that at the end of the Plan entitlement had been suitably reduced to be in line with the extraction limit. However, these provisions were never activated.

As described above, the over entitlement can be addressed by varying the allocation against each share through the annual available water determination. The Commission's view is that reducing the allocation per share through the available water determination as needed is a simple and fair way to address the over-entitlement. This is provided that the risks associated with over-entitlement are transparent, and the available water determination is suitably protective of sufficient water for stock and domestic use, utilities and the environment. If the Government intends to continue to manage over entitlement in this manner, then the provisions and associated referenced clauses for reducing entitlement[38] should be removed to avoid confusion.

The Commission acknowledges that there are inherent risks to maintaining the over-entitlement in the Plan and managing through allocation. While transparency should mitigate these risks, DoI-Water could examine opportunities to encourage surrender of unused entitlement under the new Plan to try to bring entitlement closer to available water should all licences be active.

In replacing the GAB Groundwater Plan consideration should also be given to the adequacy of the current compliance trigger for adjusting allocation, and whether this provides sufficient protection for recharge groundwater sources. Utilisation of a five year average extraction rate may not be appropriate for mitigating risks to the sustainability of the water source in the event that there is significant activation of 'sleeper licences' in a short period of time.

Recommendation:

2. The Plan should be revised to transparently indicate the current entitlement for water available for allocation to:

- provide clarity for water users that 1 share does not equate to 1ML of licensed entitlement for aquifer access licences.
- include provisions to allow for updating of licensed entitlement within a groundwater source when appropriate (e.g. due to cancellation and suspension of licences, controlled allocations and improved knowledge of water sources.)

3. DoI – Water should consider the adequacy of the current extraction limit compliance trigger for maintaining sustainable extraction in the event of significant short-term activation of sleeper licence entitlement, and if appropriate amend the trigger in the new Plan.

5.3 Protection of Groundwater Dependent Ecosystems

A key objective of the GAB Groundwater Plan is to '*protect, maintain and where possible restore priority environmental assets*'. This establishes a basis for the protection of groundwater

[37] Section 27
[38] For example, example Section 29 (10), Division 2, Section 34 (7), Part 11, Section 43 (3) and (4)

dependent ecosystems (hereafter referred to as high priority artesian springs).[39] The location of high priority artesian springs to be protected are identified in Schedule 4 of the Plan. Set-back distances that establish exclusion zones for approval of water supply works are outlined in Section 29 (2)–(6) as 5 km in recharge groundwater sources and 50 km in artesian groundwater sources. While the principles of the Plan are appropriate for the protection of high priority artesian springs, there are three major constraints limiting the ability to meet the requirements of the objective. These are as follows:

- inaccuracy of locations of artesian springs
- generic nature of set-back distances established under the Plan
- approach to works approvals that pre-date the Plan.

5.3.1 Inaccuracy of locations of artesian springs

The map in Schedule 4 of the GAB Groundwater Plan does not accurately represent the locations of high priority artesian springs. Locations currently identified in the Plan were based on data obtained in 1992, prior to implementation of GPS technology. High priority artesian springs were recorded on the basis of point source locations, rather than the current understanding of a spring complex, whereby one spring may have multiple vents in a single geographic area. For example, Peery Lake has at least 130 documented vent sites.[40]

High priority artesian spring locations mapped in Schedule 4 also pre-date research and technology that enables the identification of a groundwater source associated with a spring complex. Discussions with DoI – Water staff indicated an improved understanding of the association between groundwater sources and spring complexes may result in the removal of up to four spring locations previously identified in Schedule 4 as high priority artesian springs.

To improve the accuracy of the dataset presented in Schedule 4, the DoI - Water has undertaken site work to ground-truth the locations of high priority artesian spring complexes, including new complexes identified through recent research. The project aims to identify water sources of artesian spring complexes and prioritise them. The project is due to be completed in June 2018. Data collected aims to get an improved understanding of following key features:

- the number of spring complexes
- Aboriginal values associated with spring complexes
- identification of the groundwater source for the spring complex
- identification any pastoral uses of bore springs
- identification of endemic flora and fauna to enable prioritisation as a 'high priority artesian spring'.

The protection of high priority artesian springs through the Plan is reliant on an accurate database of spring locations. To ensure that the Plan can meet its objectives, completion of the survey work being undertaken by NSW is necessary. In addition, in recognition of the dynamic nature of spring complexes, flexibility to vary Schedule 4 of the Plan could be warranted.

[39] As highlighted in Section 3.3.1, artesian springs are the key groundwater dependent ecosystem protected under the GAB groundwater plan. For the purpose of this GAB review, and to avoid confusion, groundwater dependent ecosystems are hereafter referred to as artesian springs.
[40] Commonwealth of Australia (2014). Ecological and hydrogeological survey of the Great Artesian Basin springs – Springsure, Eulo, Bourke and Bogan River supergroups. Volume 1: history, ecology and hydrogeology, knowledge report, prepared by UniQuest for the Department of the Environment.

5.3.2 Artesian springs set-back distances established under the GAB Groundwater Plan

An interview with DoI – Water staff indicated that the set-back distances for water supply works of 5km (recharge) and 50km (artesian) groundwater sources were developed based on a combination of:

- intent to limit extraction impacts in recharge and artesian groundwater sources
- an estimated radius of interference with springs.

These distances are generic and may not adequately protect flow of artesian springs in some cases and unnecessarily restrict the development of water supply works in other cases. Advances in understanding of springs complexes, new technologies and spring classifications warrant a revisiting of this previously adopted approach. This will facilitate the development of set-back distances based on best available scientific evidence to improve environmental and socio-economic outcomes.

5.3.3 Approach to water supply works approvals that pre-date the GAB Groundwater Plan

Set-back distances for approval of water supply works were established in 2008 with the establishment of the Plan. However, several bores remain within this 'exclusion zone' as a consequence of historical bore drilling. Many of these artesian bores at or close to priority artesian springs continue to flow and have been identified as a priority for rehabilitation.[41]

As part of the Cap and Pipe the Bores program DoI – Water has promoted a 'phasing out' of bores within the set-back distance when these approach end of life. At this point, where multiple bore sites are located within the specified set-back distance, these may be replaced with a single bore site.[42] To facilitate protection of high priority artesian springs, DoI - Water should consider updating provisions to provide greater protection against drawdown where water supply works pre-date the Plan.

Recommendation:

4. To improve identification and protection of groundwater dependent ecosystems in the new Plan DoI – Water should:

- Complete the survey of artesian springs to ground-truth and nominate groundwater dependent ecosystems to be protected within the new Plan.
- Establish appropriate set back distance of water supply works based on best available scientific evidence to avoid impacting high priority artesian springs or unduly restricting works approvals.
- Update Plan provisions to establish an approach to rehabilitation of water supply works that pre-date set-back distances under the GAB Groundwater Plan to adequately protect high priority artesian springs. It is noted that this should be carried out following completion of the survey.

[41] Department of Environment and Energy (2018). The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin in Community and Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 26 April 2018.
[42] DoI – Water, Pers Comm, 11 April 2018.

5.4 Estimation and transparency of take in the GAB Groundwater Plan

5.4.1 Basic Landholder Rights

Basic Landholder Rights comprise a significant component of water permitted to be extracted across Plan area, with 7,784 registered bores in the DoI – Water database. Basic Landholder rights are used for stock and domestic purposes.

Metering of stock and domestic extraction under basic landholder rights is not required. As a result there is no visibility of water extracted for stock and domestic use from GAB groundwater sources. Inaccurate assessment of stock and domestic use could have significant impacts on the sustainability of extraction limits set in the Plan and the assessment of future water supply works approvals.

To inform allocation of groundwater under the current Plan an estimate of water requirement for basic landholder rights was developed based on stocking rates, population and property areas. The distribution of bores and current estimates of take across the GAB groundwater sources is provided in Table 7.

Table 7: Estimated water requirement from GAB groundwater sources for basic landholder rights[43]

Groundwater source	Bores	Water requirement (ML / yr)
Eastern Recharge	1,099	2,000
Southern Recharge	3,827	3,000
Surat	1,408	28,100
Warrego	687	14,300
Central	763	4,900
Total	7,784	52,300

Research into estimates of stock and domestic take under basic landholder rights has highlighted discrepancies between estimates of water take and actual take due to assumptions used to estimate extraction.[44] A new methodology has been developed that accounts for property type; volume and seasonal availability of non-groundwater supplies, seasonality of groundwater demand during wet and dry years; and distribution of estimated water use to property bores. Application of this methodology has highlighted spatial trends in stock and domestic use reflecting agro-climatic conditions, whereby GAB groundwater use increases from east to west. Testing of the method indicates reduced error margins in estimating stock and domestic use.[45]

[43] DPI Water (2015). NSW GAB groundwater sources – groundwater status report. Draft, unpublished
[44] Kier et al. (2016). Characterisation of current groundwater uses in the Surat and Bowen Basins. Poster presented at Centre of Coal Seam Gas Research review.
[45] Singh, D. (2015). A new and innovative approach to the estimation of stock and domestic groundwater use in the Surat Cumulative Management Area, Queensland. Abstracts from the Australian Groundwater Conference, 3–5 November 2015.

It is anticipated improved estimates of stock and domestic take will improve visibility of cases where extraction may be approaching the local sustainable extraction limits or where there is a need for cumulative impact assessments where stock and domestic demand is high.[46]

5.4.2 Local water utility access licences

Local water utility access licences are critical to the viability of rural communities and ensure that there is water available for town water supply. Shires that draw water from GAB groundwater sources are listed in Table 8. Utility licences are guaranteed full allocation each year. Total water utility take under the Plan increased 15% between 2008 and 2015[47]. Local utility stakeholders consulted did not anticipate significant increases in extraction over the next ten years. The GAB Groundwater Plan does not have provisions to permit the granting of local water utility access licences where this is required to meet town water supply needs. This would align provisions with other water sharing plans and be consistent with current practice within the GAB Plan area.

Table 8: Local water utility take from GAB groundwater sources

Shire Council (Utility Operator)	Access Licence Volume Shares[48]*	Population of Local Government Area**
Bourke	277	2,634
Coonamble	1541	3,918
Gilgandra	2020	4,236
Moree Plains	925	13,159
Narrabri	179	13,084
Walgett	782	6,107
Warren	740	2,732
Warrumbungle	272	9,384
Total	**6,736**	**55,254**

* Data provided by the DoI – Water from the Water Licence System Database – Accessed 5th April 2018
** Data from 2016 Australian Bureau Statistics Census

5.4.3 Aquifer interference access licences

The GAB Groundwater Plan has provisions to allow DoI – Water to issue aquifer interference access licences. Aquifer interference activities are defined under the Act as:

- the penetration of an aquifer
- the interference with water in an aquifer
- the obstruction of the flow of water in an aquifer

[46] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008
[47] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008.
[48] Plan provisions provide 100% available water determinations for local water utility access licences (1 ML per licence share) (Section 34(4)).

- the taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations
- the disposal of water taken from an aquifer.

Assessment of aquifer interference activities are conducted by DoI - Water according to the NSW Aquifer Interference Policy. DoI - Water provides advice to the Department of Planning and Environment on matters including the requirement to acquire water licences to account for take or interference with water in an aquifer, the rigour of impact predictions made by the proponent and suitability of proposed mitigation, prevention or avoidance strategies.[49]

Water licences purchased to account for take or interference with water in an aquifer as a consequence of mining, CSG extraction, extraction of sand and/or road base material are issued by DoI – Water as aquifer access licences. No aquifer interference access licences have been issued over the life of the GAB Groundwater Plan. The Commission understands that the GAB Groundwater Plan is the only water sharing plan to include an aquifer interference licence category. It is also noted that the aquifer interference licence category is not provided for in the Act. As such the Commission recommends that all provisions relating to aquifer interference access licences should be removed in the new Plan.

Activities such as mining may impose take through physical removal of water, for instance to dewater an area, or through interference with the aquifer such that water is shifted from one water source to another (referred to herein as "interference take"). DoI – Water staff have identified that the inability to distinguish within a licence between typical water take and interference take as an issue. Stakeholders identified that greater transparency around interference take within a source, which may occur many decades after the CSG extraction, is required. Department staff also indicated that the current licence and approval systems make it difficult to report on how water is allocated to extractive uses and interference take within the system.

The Commission supports greater transparency of water take associated with mining, CSG and extraction of sand and road base material. Transparency of types of take will enable DoI – Water to better track and report to the community water currently being extracted and planned to be extracted or taken through interference take. It is recognised that the impacts of depressurisation of an aquifer may take up to 200 years to materialise in a water source.[50] The visibility of timeframes for water take and aquifer interference will allow for greater assurance that these different types of 'take' are being transparently accounted for in calculations for sustainable pressure estimate equivalent and long-term average annual extraction limits. The Department staff have indicated that the simplest means to achieve the proposed transparency would be through initiating the Act provisions that require DoI-Water to issue aquifer interference approvals. The Commission recommends that DoI-Water work with the Department of Planning to determine the most efficient and effective way of improving transparency.

It is understood that the Minister determines the Divisions of the Act that are to apply in the development of a Plan. According to the GAB Groundwater Plan Division 2 (Water sharing)[51] of the Act has been applied to the development of the current Plan. In recognition of the impact of aquifer interference activities on water sharing arrangements and its importance in informing

[49] Office of Water (2012). NSW Aquifer Interference Policy.
[50] Cresswell, R. (2018). Discussion of questions raised in relation to the establishment of coal seam gas mining within the GAB region.
[51] Section 20 (1), 20 (2) (a) to 20 (e), 20 (3), 20 (4), 21 (a) to 21 (c) and 21 (f) of the Act

groundwater management decisions, the Minister should consider the extent to which Division 6 (Controlled activities and aquifer interference activities) are applicable in the development of the new Plan.

Recommendation:

5. To better reflect system take and ensure ongoing sustainability of extraction in the new Plan DoI-Water should:

- Apply the best available methodology to estimate stock and domestic requirement under basic landholder rights. At a minimum this should incorporate climate data and availability of non-groundwater sources to improve reliability of stock and domestic requirement estimates.
- Align provisions for local utility access licences with other groundwater water sharing plans to allow for ongoing town water supply.
- Provide greater transparency around water taken through aquifer interference by implementing measures to allow for identification of water allocated for aquifer interference separate from water extracted out of the system and removing aquifer interference access licences as a licence category in the Plan.
- Consider the extent to which Division 6 (Controlled activities and aquifer interference activities) of the Act should be applied in the new Plan.

5.5 Engagement with Aboriginal communities in the GAB Groundwater Plan

Cultural values are recognised as important within the Plan. However, steps can be taken to better identify these cultural values within the Plan area to enable their protection. Beyond the Plan, steps need to be taken to improve engagement with Aboriginal communities and clear guidance provided to staff to assist, where appropriate, in the enacting of the cultural licence provisions.

The Plan contains an objective to '*maintain and enhance cultural heritage values affected by the use of water from the groundwater sources*' and the performance indicator '*extent of recognition of spiritual, social and customary values of groundwater to Aboriginal people*'. The Commission has not received any data that reports against these, and it is not evident that there are clear strategies to achieve the objective.

Aboriginal artefacts are abundant at nearly all spring areas west of Bourke and include stone flakes, cores and grindstones, stone tools.[52] There are detailed records of Aboriginal legends for Cuddie springs, and where springs overlay with National Parks and State Conservation Areas, joint management committees have enabled close working relationships with indigenous communities and works to preserve sites of high Aboriginal cultural value.[53]

[52] Commonwealth of Australia (2014). Ecological and hydrogeological survey of the Great Artesian Basin springs – Springsure, Eulo, Bourke and Bogan River supergroups. Volume 1: history, ecology and hydrogeology, knowledge report, prepared by UniQuest for the Department of the Environment.
[53] National Parks and Wildlife Service (2012). Paroo-Darling National Park and State Conservation Area – Plan of Management.

The Aboriginal Water Initiative[54] developed a database of culturally sensitive water dependent sites from Traditional Owners throughout NSW to facilitate protection of these sites during water planning processes.[55] The Commission did not have access to the database to determine the identification of sites of Aboriginal importance in the Plan area.[56] However, this would provide a sound basis for more clearly identifying important cultural sites within the Plan area.

To ensure recognition of groundwater values to Aboriginal communities, more effective consultation is required. The database developed through the Aboriginal Water Initiative, research reports and land management plans could inform consultation with Aboriginal communities to identify Aboriginal values in the Plan area.

Consistent with the Act, a native title holder is entitled, under the GAB Groundwater Plan, to take and use water in exercise of native title rights without the need for an access licence, water supply work approval or water use approval (Section 55 (1)). No native title rights apply to the Plan area.

The Plan additionally establishes provisions for Aboriginal communities to apply for water access licences. These are detailed in Section 28(4) where:

An access licence of the subcategories Aboriginal cultural or Aboriginal community can only be granted if the application does not exceed:

- *10ML/year for an aquifer (Aboriginal cultural) access licence, and*
- *50ML/year for an aquifer (Aboriginal community) access licence.*

Cultural licences can be used for the purposes of manufacturing traditional artefacts, hunting, fishing, gathering, recreation and ceremonial purposes. It is understood that cultural access licences are active for the life of the cultural purpose and must be renewed on an annual basis.[57] There have been no Aboriginal cultural or Aboriginal community licences registered over the period of operation of the Plan.

There are a number of challenges regarding engagement with Aboriginal communities in water planning processes.[58] Possible explanations for low levels of uptake of Aboriginal cultural and community licences are:

- a lack of awareness of Aboriginal cultural and Aboriginal cultural licences
- complex approvals processes that may be a barrier for Aboriginal communities applying for the licence
- lack of familiarity of DoI - Water staff with licence conditions and potential for application
- low rates of land ownership to access and use water obtained under an Aboriginal cultural or Aboriginal community licence
- concerns regarding restrictions applied to Aboriginal cultural and Aboriginal community licences

[54] The Aboriginal Water Initiative ran from 2012–2016 and aimed to improve indigenous representation in water planning and management.
[55] Hartwig, L. and Jackson, S. (2017). Submission to the Productivity Commission National Water Reform public inquiry, Draft report released 15 September 2017.
[56] The Commission notes that access to the Aboriginal Water Initiative database is associated with cultural sensitivities.
[57] National Water Commission (2014). A review of Indigenous involvement in water planning, 2013
[58] It is noted that these challenges extend beyond the GAB Groundwater Plan

- infrastructure costs with obtaining a licence e.g. bore construction.[59], [60]

The challenges highlighted above point towards the need for a guidance document on Aboriginal cultural and Aboriginal community licences. The Commission notes that there is an existing factsheet produced by the NSW Local Aboriginal Land Council related to water licencing in NSW;[61] however, this could be updated to give more specific guidance on Aboriginal cultural and Aboriginal community licences. This would be of benefit for both Aboriginal communities, DoI - Water staff assisting and/ or approving licencing applications and any regulatory staff made under the new plan.

Recommendation:

6. In developing the new plan, DoI-Water should consult with Aboriginal communities to identify groundwater sites of Aboriginal spiritual, social and customary value, and clarify the objectives and performance indicators in relation to cultural values. The new Plan should include provisions that identify (or nominate a database location) for cultural values within the GAB Groundwater Plan area.

Suggested action: DoI-Water should consider developing a guidance document on Aboriginal cultural and Aboriginal community licences to support Aboriginal communities and DoI - Water staff with licencing applications, approvals and regulation.

5.6 Changing administrative boundaries for the GAB Groundwater Plan

5.6.1 Shifting of groundwater source boundaries

According to Schedule 2 (the registered map of GAB groundwater sources) and associated Plan provisions, the GAB Groundwater Plan is currently divided into five groundwater sources. The establishment of groundwater source boundaries allows for the adoption of different management approaches. The Central, Warrego and Surat groundwater sources are managed to maintain artesian pressure. The Eastern and Southern Recharge groundwater sources are managed to maintain extraction below sustainable recharge levels.

Within the Plan the five zones have separate rules, such as different extraction limits or sustainable pressure estimate equivalents. Therefore, it is important that the boundaries between the zones be properly defined.

The current boundaries of the GAB groundwater sources were defined using knowledge of GAB boundaries in the 1990s. An improved understanding of the hydrodynamics of the GAB has generated a greater appreciation of interaction of the groundwater sources. As a result of this new information, a review and adjustment of groundwater source boundaries should be undertaken in development of the new plan.

[59] National Water Commission (2014). A review of Indigenous involvement in water planning, 2013
[60] Hartwig, L. and Jackson, S. (2017). Submission to the Productivity Commission National Water Reform public inquiry, Draft report released 15 September 2017.
[61] NSW Local Aboriginal Land Council (2013). Water Licences Factsheet. Available at http://alc.org.au/media/86707/Water%20Licences%20Fact%20Sheet.pdf

Research undertaken in 2015 documented an improved understanding of groundwater flow lines throughout the GAB (Figure 7).[62] An assessment of groundwater flow lines in the recharge groundwater sources indicates a clear flow from east to west up to the zone of separation with the Surat groundwater source. This is consistent with the current Plan and does not indicate a need for adjustment of the recharge groundwater source boundaries.

Groundwater flow lines highlight zones of separation where groundwater is not expected to flow between the Central, Surat and Warrego groundwater sources. These zones of separation highlighted via flow paths are further supported by maps of hydrochemical distinctions (distribution of sodium absorption ratios across the GAB - Figure 8) and isotopic trends (Figure 9)[63].

Technical advice regarding the mapping of flow lines, hydrochemical distinctions and isotopic trends supports a shifting of the boundaries of the Warrego groundwater source 150km west of its current location through the natural break in bore distributions west of the Paroo River. The Eastern boundary could be located 50km east of its current location closer to the course of the Narran River.[64]

Assessment of current distribution of bores indicates this shift would have little impact to licencing of artesian bores as these appear to reflect the groundwater source boundaries defined above. However, sub-artesian bores may require reclassification into a different groundwater zone than they are currently allocated.

[62] Ransley et al. (2015). Hydrogeological Atlas of the Great Artesian Basin. Geoscience Australia, Canberra. Available at https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search?node=srv#/metadata/fa97cd2a-bf57-2720-e044-00144fdd4fa6

[63] Ibid. See footnote 62.

[64] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008

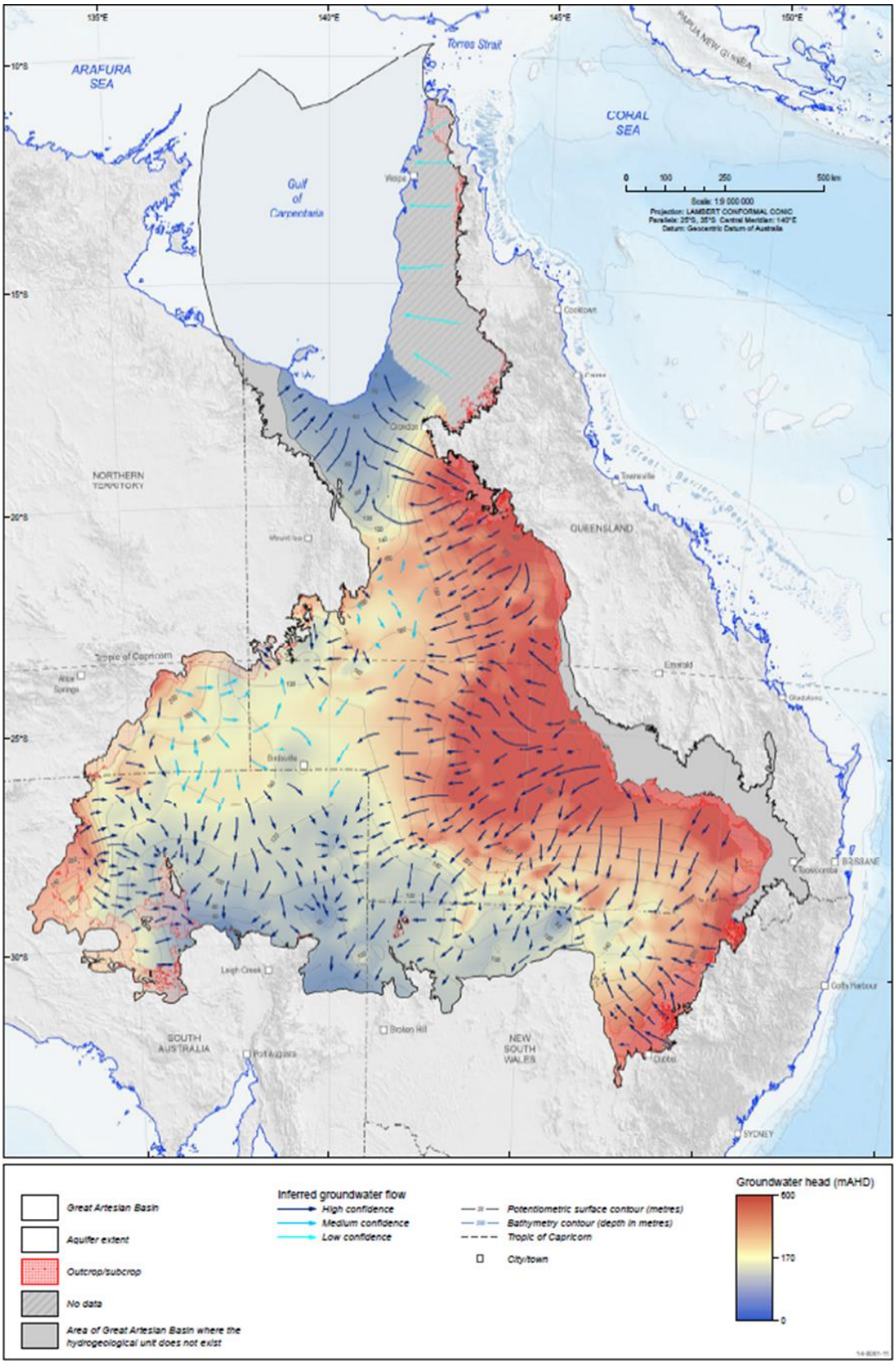

Figure 7: Groundwater flow paths in the GAB[65]

[65] Ransley et al. (2015). Hydrogeological Atlas of the Great Artesian Basin. Geoscience Australia, Canberra. Available at https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search?node=srv#/metadata/fa97cd2a-bf57-2720-e044-00144fdd4fa6

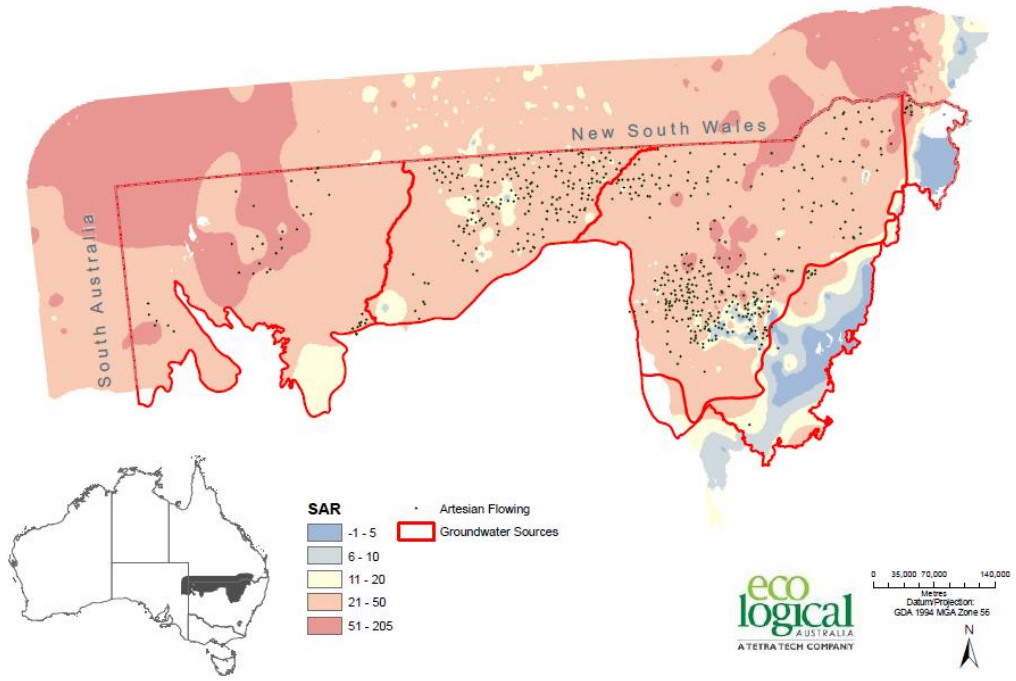

Figure 8: Sodium Absorption Ratio of NSW GAB groundwater sources[66]

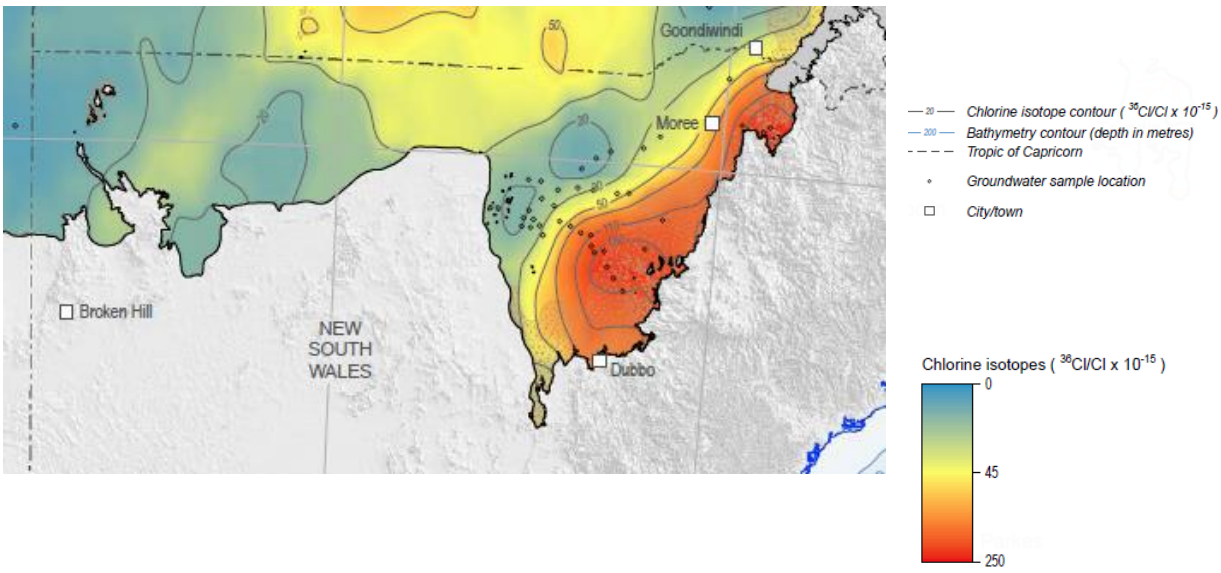

Figure 9: Chlorine isotope ratios for the NSW GAB groundwater sources[67]

The changes to the Warrego groundwater source boundary will ensure that its comparatively shallow depth, higher quality water source is managed separately to the poorer quality immediately adjacent zones of the Surat and Central groundwater source. It will also manage

[66] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008

[67] Ransley et al. (2015). Hydrogeological Atlas of the Great Artesian Basin. Geoscience Australia, Canberra. Available at https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search?node=srv#/metadata/fa97cd2a-bf57-2720-e044-00144fdd4fa6

the higher concentration of artesian bores in the Warrego groundwater source relative to the Surat and Central groundwater sources, assisting in ongoing management on artesian pressures (Figure 10).

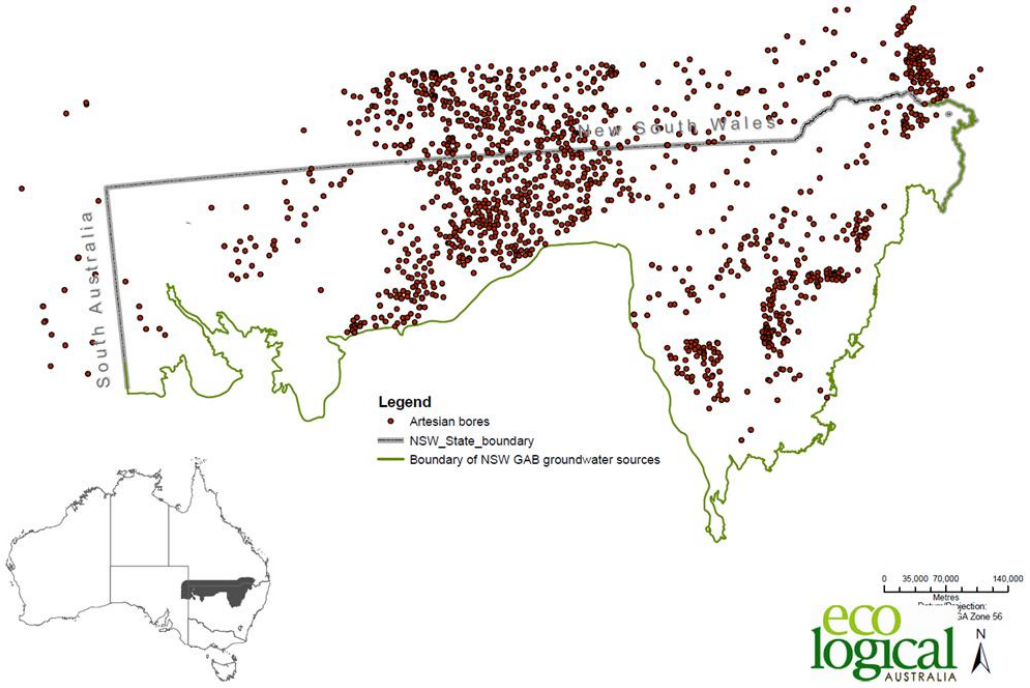

Figure 10: Distribution of registered artesian bores in the NSW GAB[68]

5.6.2 Relationship between the GAB Shallow Plan and GAB Groundwater Plan

The GAB groundwater Plan establishes a separation to the GAB Shallow Plan, defining the boundary between the two plans as '*water contained in all rocks of Cretaceous and Jurassic age at a depth of more than 60 metres below ground level within the Surat (…), Warrego (…) and Central groundwater sources*' (Section 5 (4)). It is noted that Eastern and Southern Recharge groundwater sources does not include the 60m boundary and includes '*water contained in all rocks of Cretaceous, Jurassic and Tertiary age, and all alluvial sediments*' (Section 5 (3)).[69]

The separation of GAB shallow and GAB groundwater sources was developed to:

- Principally, recognise the different modes of recharge between GAB shallow and GAB artesian groundwater sources. This facilitated the adoption of different management approaches to the NSW GAB whereby the GAB shallow aquifers could be managed according to estimates of recharge and the GAB artesian groundwater sources was managed to maintain pressure equivalent volumes.
- Establish a boundary between the GAB Groundwater Plan and the GAB Shallow Plan. This boundary roughly corresponds to the maximum depth of unconsolidated sediments

[68] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008. NB: No distinction on take by registered bores is defined in Figure 10. Map developed using data derived from the Ransley et al. (2015).
[69] It is noted that the Eastern and Southern Recharge groundwater sources excludes some alluvial groundwater sources located in the Lower Macquarie region as defined in Schedule 2 (Registered Map)

sources where recharge is direct; however, it is recognised that the thickness of these sediments are non-uniform across the artesian groundwater sources. [70]

Advances in understanding of the hydrogeology has established a need to revise the currently established separation boundary between the GAB Shallow and GAB Groundwater Plans.

The GAB Shallow Plan and GAB Groundwater Plan were amended in 2011. The Commission understands that this was principally to more clearly separate the two plans and establish a boundary between the Plans. The thickness of 60m used in developing the separation boundary between the Plans is not reflective of the actual geological non-uniform thickness of the unconsolidated sediments.[71] Application of this Plan boundary has resulted in 'grey areas' for DoI – Water staff. This occurs where a bore will not actually be drilled into artesian groundwater sources; however due to the Plan boundary at 60m the approval framework triggers consideration of the requirements of the GAB Groundwater Plan as opposed to the GAB Shallow Plan. This has implications for the assessment process, as the Plan boundary triggers whether impacts determined during the water supply works process are calculated according to the maintenance of artesian pressures or recharge estimates. Establishment of a boundary that recognises where recharge is no longer direct (via the unconsolidated sediments) will allow for the application of the management approach that is relevant to the groundwater source being assessed. Stakeholder feedback received during the consultation process also highlighted stakeholder confusion in the justification for the separation of the GAB Shallow and GAB Groundwater Plans.

Research undertaken following the 2011 amendment to separate the GAB Shallow and GAB Groundwater Plans has established connectivity between the shallow and groundwater sources, and provides an evidence basis for the merging of the two plans. It is acknowledged that merging of the plans does not establish a uniform approach to management of the groundwater resources, but will allow for the shallow and groundwater plans to 'speak' to each other in recognition of the inter-source exchange. The GAB Water Resource Assessment (Smerdon et al., 2012) demonstrated significant vertical flux for different GAB aquifers and the location of surficial channels (called paleochannels) as an indicator for downward leakage of water. As highlighted in Figure 11 these paleochannels overlie much of the NSW GAB Groundwater Plan area indicating connectivity between surficial and GAB artesian groundwater sources.

Connectivity of the GAB with overlying aquifers has additionally been highlighted in areas of the Lower Namoi Alluvium. In these areas it has been noted that the artesian contribution to alluvial groundwater sources is as high as 70%, with a continuum of exchange between the alluvial aquifer and the GAB.[72]

[70] Ransley et al. (2015). Hydrogeological Atlas of the Great Artesian Basin. Geoscience Australia, Canberra and Kellet et al (2012). Water Resource Assessment for the Surat region. A report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment. CSIRO Water for a Health Country Flagship, Australia.
[71] Ibid. See footnote 70.
[72] Iverach, C.P., Cendon, D. I., Meredith, K. T., and Kelly, B. F. J. (2017). A multi-tracer approach to constraining artesian groundwater discharge into an alluvial aquifer. Hydrology and Earth Systems Sciences Discussions, 21 (11): 1–40.

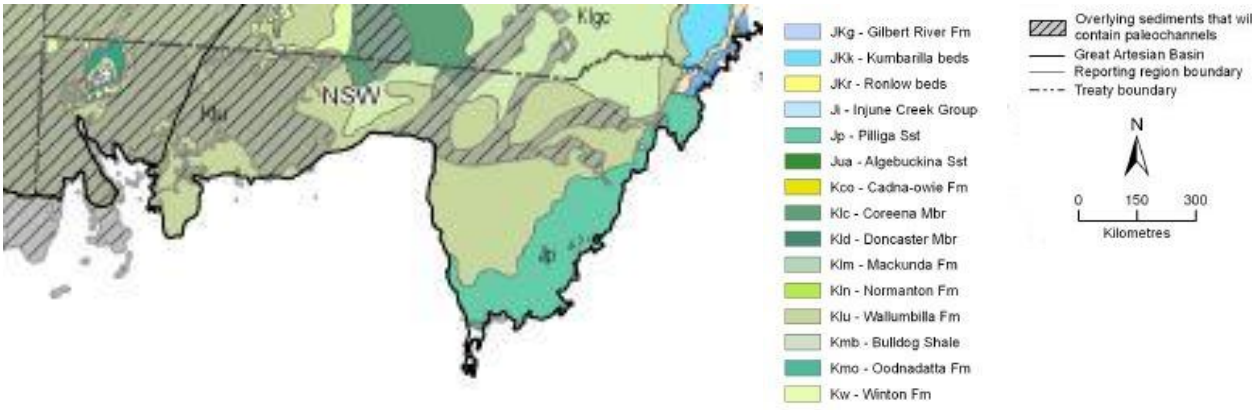

Figure 11: Extent of Cenozoic deposits highlight paleochannels in the NSW GAB

Publicly available information and feedback from DoI -Water indicate two potential planning options that may impact on the boundaries established via the GAB Shallow and GAB Groundwater Plan are currently being considered:

- the GAB Shallow Plan is linked with the extensive alluvial systems that are managed under separate Water Sharing Plans considered within the Murray Darling Basin Plan.[73]
- merging of the GAB Shallow Plan with the GAB Groundwater Plan.[74]

The merging of the GAB Shallow and GAB Groundwater Plans would represent a cleaner solution, providing greater clarity for users than inclusion under multiple Murray-Darling Basin Plans.[75] It is understood that merging of the Plans will require complementary changes to the Basin Plan that will not be achievable in the short-term. Timeframes to enable this to occur will need to be determined.

It is recognised that that there are many aspects to consider in making a decision to merge Plans and the advantages and disadvantages to the division of the resource will require consideration. Issues to consider to determine resource allocation and management include:

- characterisation of recharge including location of recharge, recharge quantities and recharge pathways with qualification of uncertainties in assumptions.
- lateral movement of water between aquifers including across aquitards and across administrative boundaries to assist in groundwater management.

[73] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008.
[74] Department of Industry – Water. NSW Great Artesian Basin Groundwater. Available at http://www.water.nsw.gov.au/water-management/water-sharing/plans-commenced/water-source/gab. Accessed 12 January 2018.
[75] Ibid. See footnote 73.

Recommendation:

7. Administrative boundaries should be updated by DoI – Water in the new Plan to:

- Redefine the boundaries of the Warrego groundwater source as defined in Schedule 2 based on latest available knowledge.
- Re-classify registered bores impacted by the change in the Warrego groundwater source boundaries and notify affected licence holders.
- Merge the NSW GAB Shallow and GAB Groundwater Plan in recognition of the constraints imposed by continuing to separate the Plans at the currently defined boundary of 60m, and to assist in groundwater management across administrative boundaries.

5.7 Improving clarity of the GAB Groundwater Plan

A number of stakeholders, including DoI – Water staff, identified issues associated with the clarity of the GAB Groundwater Plan. Improvements to Plan clarity could be facilitated through:

- simplification of plan terminology
- adoption of Plan explanatory notes
- logically linking objectives, strategies and performance indicators in the new Plan.

A brief discussion of suggested changes to improve overall Plan clarity are outlined below.

Beyond the GAB Groundwater Plan, the guide and background documents act as significant references for communication of water use in the GAB, administrative boundaries and water trading rules in the Plan. The most recent guide and background documents for the GAB Groundwater Plan were as issued in 2009. Since this time, DoI – Water have improved the templates for the guideline and background documents through the development of other water sharing plans. To avoid confusing GAB stakeholders by referring to outdated documents (the GAB Groundwater Plan was amended in 2011) an update to the guide and background document will be required.

5.7.1 Adjustment of Plan template

Stakeholders have raised a number of specific concerns in relation to the Plan, some of which have already been outlined in this report (e.g. clarity of extraction limits, boundaries and links to other plans). DoI- Water should work with stakeholders to understand the areas of the Plan that create confusion for water users, where additional clarity is required, and develop a simplified layout for the new plan.

Improvements to water sharing plan templates for groundwater sources have been made by DoI – Water. These are reflected in the GAB Shallow Plan, which was updated in 2011 to include explanatory notes throughout the Plan. These improved approaches should be applied to the new GAB Groundwater Plan.

It is recognised that there is some necessary complexity in the GAB Groundwater Plan as a consequence of geological terminology used to define Plan boundaries and concepts associated

with artesian pressure. Some of this complexity could be readily explained through the use of additional diagrams, maps and cross-sections in the guide and background documents for the plan. In addition, efforts should be made during Plan replacement to simplify Plan language where possible. Efforts should be made to ensure that consistent terminology is applied across groundwater sharing plan templates, and clarity in drafting to avoid any 'grey areas' in the interpretation of Plan provisions.

5.7.2 Logically linked objectives, strategies and performance indicators

The current GAB Groundwater Plan does not adopt a logical approach to the development of objectives, strategies and performance indicators. When viewed in isolation, the objectives and strategies are for the most part logical and simple. However, there is no clear link between the strategies and how they will deliver the desired objectives.

In developing the replacement GAB Groundwater Plan, effort should be taken to demonstrate the logical linkages between objectives and strategies. For example, in the current GAB Groundwater Plan the objective '*maintain and enhance cultural and heritage values affected by the use of water from the groundwater sources*' there is no clearly linked strategy that will enable the delivery of this objective.

The ability of the Plan to measure its achievement would be significantly improved through the drafting of specific performance indicators that allow the users of the GAB Groundwater Plan to clearly understand the intended targets. For example, '*change in groundwater levels and pressures*' does not clearly indicate that the Plan is hoping to achieve pressure recovery and may be simplified to reflect recovery in hydraulic head.

Recommendation:

8. To improve overall clarity of the new Plan DoI – Water should:

- implement a simplified template and consistent terminology
- clarify aspects of the plan that create confusion based on input from stakeholders including extraction limits, Plan boundaries and links to other water sharing plans.
- update the objectives, strategies and performance indicators in the new plan. These should be logically linked and specific to enable the monitoring and delivery of GAB Groundwater Plan outcomes.

5.8 Current NSW Government initiatives underway

The Commission has identified three issues in the review that will be addressed through the implementation of NSW Government initiatives and cross-jurisdictional planning processes currently underway. These are outlined in Section 5.8 along with the relevant policy or planning process that will resolve the identified issue.

5.8.1 Metering of access licence extraction

All 381 production bores in the GAB Groundwater Plan that are covered by an access licence (aquifer access licence, local water utility licence access licence, domestic and stock licence) are required to have a meter under mandatory conditions enforced via the Plan (Section 49).[76]

[76] Bores in the GAB that do not have aquifer access licence and are constructed under Basic Landholder Rights are required to go through a water supply works approval process.

The DoI – Water has indicated that data provided from these production bores is sporadic.[77] Collection of accurate metering data is necessary to ensure that the actual water extraction is understood and calculations for allocation are well-informed. Steps should be taken to improve the collection of this data and ensure that the mandatory condition is being followed and enforced.

A key pillar of the Water Reform Action Plan focuses on water take management and metering. Policies developed under this metering policy should be applied in the replacement of the GAB Groundwater Plan. Application of this updated policy will improve the assessment of impacts and available water determinations enforced under the GAB Groundwater Plan.

It is noted that metering will not apply to Basic Landholder Rights; however as discussed in Section 5.4.1, application of the best available methodology will improve the reliability of stock and domestic extraction.

5.8.2 GAB Coordinating Committee Strategic Management Plan

The GAB Coordinating Committee has been working towards the development of the next Strategic Management Plan following the expiry of the previous Plan in 2015. The Strategic Management Plan is currently under stakeholder consultation and will be agreed to and released in 2018.

The GAB Coordinating Committee Strategic Management Plan will establish key commitments for the NSW State Government, including priority areas for investment and reform. Commitments made under the 2018 Strategic Management Plan will need to be captured in the new GAB Groundwater Plan.

5.8.3 Reasonable use guidelines for Stock and Domestic extraction

The Commission understands that it is the intention of the NSW Water Reform Taskforce to introduce a reasonable use guideline for stock and domestic usage extracted under Basic Landholder Rights. The guideline document will proceed through a stakeholder consultation process in 2019. This guideline should be considered in the development and design of groundwater management approaches to stock and domestic take under basic landholder rights within the new GAB Groundwater Plan.

Recommendation:

9. In developing the new plan, DoI - Water should complete current efforts to:

- Apply metering policies developed under the Water Reform Action Plan to improve assessment of impacts and available water determinations enforced via the Plan.
- Incorporate NSW Government commitments made under the GAB Coordinating Committee Strategic Management Plan.
- Integrate any finalised policy positions developed through the reasonable use guideline for Basic Landholder Rights (stock and domestic usage).

[77] Cresswell, R. (2018). Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the Water Sharing Plan for the Great Artesian Basin groundwater sources 2008.

Appendix A

The Commission developed eight questions to determine the contribution of the Plan to State Priorities to Local Land Services. These were included in the call for submissions on the *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008*. Non-confidential submissions received were made public on the Commission's website.

1 In what ways have the plan provisions materially contributed to these goals?

2 What changes to plan provisions are warranted to better achieve these goals?

3 How could plan provisions be improved to reduce complexity and cost of implementation?

4 How could plan provisions be improved so that regulatory obligations on businesses are reduced or made easier to understand and implement?

5 How could plan objectives, performance indicators, monitoring and reporting be improved?

6 How could plan provisions better address risks, commensurate with benefits and costs?

7 Is the knowledge on which the plan provisions are based commensurate with the potential level of risk, scale and local importance?

8 Is there significant new information on the underpinning science and assumptions?

Appendix B

Document name	Date	Source
A multi-tracer approach to constraining artesian groundwater discharge into an alluvial aquifer	2017	Iverach, C.P., Cendon, D.I., Meredith, K.T. and Kelly, B.F.J.
A new and innovative approach to the estimation of stock and domestic groundwater use in the Surat Cumulative Management Area	2015	Office of Groundwater Impact Assessment
An investigation of the Stygofauna Community in the Pilliga Area 2016–17	2017	Dr Peter Serov
Annual Report 2015–2016	2016	Great Artesian Basin Coordinating Committee
Background review - Bore integrity	2014	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development and Department of the Environment
Characterisation of current groundwater uses in the Surat and Bowen basins	2016	Keir, G., Bulovic, N., McIntyre, N. and Callow, I.
Ecological and hydrogeological survey of the Great Artesian Basin springs - Spingsure, Eulo, Bourke and Bogan River super groups. Volume 1: history, ecology and hydrogeology	2014	Department of Environment
Economic output of groundwater dependent sectors in the Great Artesian Basin. A report Commissioned by the Australian Government and Great Artesian Basin jurisdictions based on advice from the Great Artesian Basin Coordinating Committee.	2016	Frontier Economics
Evaluation of the Cap and Pipe the Bores Program - Program Evaluation	2016	NSW Department of Industry
Future directions for the Management of the Great Artesian Basin - A review of the strategic management plan	2015	Great Artesian Basin Coordinating Committee
Great Artesian Basin - Resource study 2014	2016	Great Artesian Basin Coordinating Committee
Great Artesian Basin Recharge Systems and Extent of Petroleum and Gas Leases - Second Edition	2015	Robert Banks

Great Artesian Basin Strategic Management Plan: Progress and Achievement to 2008	2009	Great Artesian Basin Coordinating Committee
Hydrogeological Atlas of the Great Artesian Basin	2016	Geoscience Australia
Inland groundwater water sharing plan audit report cards	2014	DOI Water
NSW Aquifer Interference Policy Factsheets	2013	Great Artesian Basin Coordinating Committee
NSW Great Artesian Basin groundwater - website information		DOI Water
NSW Great Artesian Basin groundwater sources - background document	2009	Department of Water and Energy
NSW Great Artesian Basin Groundwater Sources - Groundwater status report 2015	draft, unpublished	DOI Water
NSW Great Artesian Basin groundwater sources - guide	2009	Department of Water and Energy
NSW Great Artesian Basin water auction 2009 - final report	2010	NSW Office of Water
NSW Monitoring, Evaluation and Reporting Program. Technical Report Series Groundwater	2010	NSW Government
Paroo - Darling National Park and State Conservation Area. Plan of Management .	2012	Office of Environment and Heritage
Submission to the Productivity Commission National Water Reform public inquiry	2017	Hartwig., L. and Jackson, S.
Summary of part drilling activity within the Great Artesian Basin	2017	Great Artesian Basin Coordinating Committee
Technical advice related to groundwater issues, particularly the Great Artesian Basin, arising from review of the water sharing plan for the Great Artesian Basin groundwater sources 2008	2018	Richard Cresswell
The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin in community and species profile and threats database	2018	Department of Environment and Energy
Water availability in the Murray-Darling Basin: A report from CSIRO to the Australian Government	2008	CSIRO
Water licences	2013	Local Aboriginal Land Council
Water resources assessment for the Great Artesian Basin. A report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment	2012	Smerdon BD, Ransley TR, Radke BM and Kellett JR

Water Sharing Plan for the NSW GAB Groundwater Sources 2008	Last Modified 14 February 2014	Legislation
Water Sharing Plan NSW Great Artesian Basin Shallow Groundwater Sources - Background document	2011	Office of Water
Water trade analysis for water sharing plan reviews. Analysis of water trade for the Bellinger River, Border Rivers and Great Artesian Basin water sharing plans.	2018	Aither

Appendix C

Alignment between Local Land Services state priorities and objectives of the GAB Groundwater Plan

	Local Land Services state priorities		
GAB Groundwater Plan objectives	**Resilient, self-reliant and prepared local communities**	**Biosecure, profitable, productive and sustainable primary industries**	**Healthy, diverse and connected natural environments**
improve pressures and flows in the artesian portion of the groundwater sources through efficient water use and achieve sustainable extraction in their recharge areas	✓	✓	✓
protect, maintain and where possible restore priority environmental assets	✓		✓
maintain and enhance cultural and heritage values affected by the use of water from the groundwater sources	✓		
enhance groundwater use for community benefit	✓	✓	
adaptively manage these groundwater sources	✓	✓	✓
protect groundwater quality	✓	✓	✓

Appendix D

Description of NSW GAB groundwater sources[78]

Water source description	Groundwater source							
	Eastern Recharge	Southern Recharge	Surat		Warrego		Central	
			Pilliga sandstone	Mooga sandstone	Hooray sandstone	Mooga sandstone	Hutton / Hooray sandstone	Mooga sandstone
Predominant bore type	Subartesian	Subartesian	Artesian		Artesian		Artesian	
Aquifer depth	60–400m	50–350m	400–1,300m	220–350m	400–750m	200–350m	400–900m	200–400m
Flow of artesian bores	4 L/s	3 L/s	45 L/s	20 L/s	55 L/s	15 L/s	35 L/s	Low flow
Salinity levels of artesian bores[79]	1,500 µS/cm	1,300 µS/cm	1,000–2,000 µS/cm	1,000–3,000 µS/cm	1,000–3,000 µS/cm	2,000–5,000 µS/cm	1,500–3,000 µS/cm	-
Artesian head	0.5–24m	0.5–4m	10–52m	Few metres–20m	20–50m	-	Few metres–30m	-
Temp. of artesian groundwater	23–29°C	23–28°C	35–58°C	25–30°C	35–48°C	25–30°C	58–74°C	25–33°C
Dominant industries	Stock, domestic, irrigation	Stock, domestic, industrial, irrigation, town water supply	Pastoral, domestic, town water supply, spa bath industry, opal mining		Pastoral, domestic, town water supply		Pastoral, domestic water supply	
Industry constraints	Low salinity / sodium levels suitable for irrigation	Low salinity / sodium levels suitable for irrigation	High sodium content, unsuitable for irrigation. Mixing of surface / groundwater near Narrabri for irrigated production[80]		Predominantly high sodium content, unsuitable for irrigation. Use in areas of lower sodium concentration is restricted by lower flow rates[81]		High sodium and salinity content, unsuitable for irrigation	

[78] DPI Water (2015). NSW GAB groundwater sources – groundwater status report. Draft, unpublished.
[79] Salinity values exceeding 500 µS/cm are deemed undesirable for irrigation purposes. NSW DPI (2016) Interpreting water quality test results. Primefact 1344.
[80] R Cresswell (pers comm)
[81] Ibid. See footnote 80.