The University Of Queensland
AUSTRALIA

Centre for Natural Gas

UQ Centre for Natural Gas: Annual Research Review workshops

Acknowledgements

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Disclosure

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For more information about the Centre's activities and governance see natural-gas.centre.uq.edu.au

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The Australian Code for the Responsible Conduct of Research outlines expectations and responsibilities of researchers to further ensure independent and rigorous investigations.

This report has not been independently peer reviewed.

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1 Introduction

The University of Queensland Centre for Natural Gas Annual Research Review was held on Thursday 12 December 2019.

The review included the following three workshops:

- Challenges in the communication of technical information
- Walloons Springbok interface: when is an aquifer not an aquifer?
- What's new in understanding the Great Artesian Basins – the research is in, what's next

This document provides a brief summary of the discussions at each of the workshops, along with a copy of the presentations.

Please email naturalgas@uq.edu.au if you have any enquiries regarding the workshop or if you wish to know more about the Centre's research program.

2 Concurrent workshops

2.1 Challenges in the communication of technical information

Workshop host:
Dr Kathy Witt, Senior Research Fellow, UQ Centre for Natural Gas (k.witt@uq.edu.au)

Workshop summary:

Kathy facilitated a very open, interactive discussion with the participants on this issue, using the Powerpoint slides as discussion prompts (Appendix A). The participants were very engaged throughout the workshop, contributing many practical details from their diverse experiences and raising many interesting observations regarding the changing community expectations around information sharing and engagement processes.

1. At the commencement of the workshop, Mr Bill Date, Chief Inspector, Petroleum and Gas Inspectorate, Department of Natural Resources, Mines and Energy took the opportunity to share learnings from the Inspectorate's experience in communicating with community members regarding the coal seam gas (CSG) industry. Bill raised the following key points:
   - Technical communication is not much of an issue now. It was more relevant in the past.
   - One of the main issues is a lack of understanding of how the CSG industry operates.
   - Technical information is not enough. A communications strategy must have a mix of information sharing and practical experience e.g. tours of facilities. Also, communications must be a mix between technical and plain English to be effective.
   - Must have: consistency of messages and information between companies, across the region and over time. People will remember information they have been given and will question any perceived changes.
2. An important first step is being clear about the purpose of communicating technical information. The group discussed their views regarding the main purpose for communicating technical information:
   - We need to initially educate and inform the public in order to influence opinions and build trust.
   - Communication is different to community engagement. We should acknowledge them as separate concepts for the discussion even though they are interconnected.
   - The community like being presented to – they respect the attempt even if it isn't perfect.
3. Discussion of informal survey about fracking:
   - NGO's and environmental organisations are the main source of information considered by general public.
   - People surveyed mostly thought they knew a little about fracking and wanted to know more, although some didn't. Knowing more would not necessarily change peoples' opinions.

- The aspects of fracking that people wanted to know more about are related to water use and management during the fracking process, potential future water impacts, other potential future effects (land related) and climate effects. People did not identify technical information about fracking (i.e. how it is done) as a priority. When presenting information about fracking we should be prepared to answer, “Why do we need to frack?” and “Why have other governments banned fracking?”.
- The annual OGIA Underground Water Impact Report updates were considered helpful and were thought to contribute to lower rates of complaints, questions and comments from the public.
- Making information available for landholders regarding bore failure has helped them to understand that there are multiple causes of bore failure and they look for other answers before blaming CSG production.

4. Discussion regarding increasingly powerful discourses e.g. climate activism, human rights, emissions reporting and the extent to which the gas industry should engage in such discourses:
    - Communications (as presented in the media) have been mostly value-driven (not technical) and very polarised.
    - As a result, many people don’t understand the complexities of the issues and have unrealistic expectations regarding what can be done in the short term.
    - There were 14 enquires into fracking in AU and all of them show risks, but also that risks can be managed to acceptable levels.
    - There are at least two different audiences in this debate: local people (especially landholders – who understand the issues better now and have been more accepting of industry) and urban residents with environmental concerns.
    - Some of the heat re CGS industry amongst farmers has diminished and UQ Centre for Natural Gas research shows trust has increased among this group.
    - Fear of the unknown. Do you overcome fear with technical information? Facts alone won’t do the job. Feelings must be acknowledged and we must empathise and address them, not only respond in a technical way.
    - The gas industry is being drawn into these types of discourses – mainly around climate action and desired energy futures.
5. The gas industry can be more effective in communicating its contributions to the Sustainable Development Goals (SDGs) indicative priorities.

The mining industry (and recently the offshore gas industry) has undertaken this analysis to understand, measure and communicate their contribution to the SDGs. Other industries e.g. in the agricultural sector, have also completed this assessment process and are explicitly aligning their operations with the SDGs. The group commenced the following group activity, but unfortunately had limited time to devote to this discussion.

The group agreed that SDG 13, the Climate Action goal was a priority for the gas industry and an area where it could make a major contribution. Other priority SDGs were SDG 7 Affordable and Clean Energy; SDG 8 Decent work and economic growth; SDG 9 Industry, Innovation and Infrastructure. Further analysis would highlight other less obvious but also significant areas of contribution e.g. partnerships, where the onshore gas industry makes positive contributions to progressing the SDGs.

Conclusion:

- Technical communication is important but there are challenges where the dominant discourse is values-driven. Different sectors in the community desire different levels of detail.
- Technical information is not enough where there is strong emotion, 'outrage', or fear.
- Activists communicate with a lot of 'certainty', as opposed to the cautious scientific approach adopted by researchers and industry.
- Technical information should be complemented with information about how the industry contributes to the common goals of society (e.g. SDGs, shared value).

2.2 Walloons Springbok interface: when is an aquifer not an aquifer?

Workshop host:
Professor Suzanne Hurter, Energi Simulation Industrial Chair in (Unconventional) Onshore Gas Reservoir Modelling, UQ Centre for Natural Gas

Workshop summary:

A section of 48m core from well Dalwogan 19 was made available by Origin Energy to be viewed. It included the Walloon to Springbok transition with about 26m of Springbok.

The vertical heterogeneity in lithologies across the Walloons and Springbok could be clearly observed. The interval identified as Springbok is quite variable at this location, so its flow properties would likely also be variable. This vertical variability translates also into a similar lateral variability. Discussions at the core evolved around the scale of individual depositional settings, i.e. the lateral extent as compared with the vertical scale and that a time equivalent surface can cross over differing lateral depositional environments. In a gross depositional environment such as a lower delta plain (the current view at the UQ Centre for Natural Gas on the depositional environment), the relief logically cannot be more than a channel can be thick, otherwise that is where the channel would migrate. The Springbok/Walloons interface concept has to be time equivalent and not lithology equivalent

The workshop was presented in an interactive classroom discussion style.

2.3 What's new in understanding the Great Artesian Basins – the research is in, what's next

Workshop host:
Professor Phil Hayes, Chair of Water Resources and Gas Development, UQ Centre for Natural Gas, phil.hayes@uq.edu.au

Workshop summary:

This workshop was presented in a panel style format

Panel Chair:
- Assoc Prof Phil Hayes, Chair of Water Resources and Gas Development

Presenters/Panellists:
- Carlos Miraldo Ordens, Research Fellow, Centre for Water in the Minerals Industry
- Craig Walton, Principal Policy Officer, Department of Natural Resources, Mines & Energy
- Neil McIntyre, UQ Amplify Research, Centre for Water in the Minerals Industry

Dr Carlos Ordens presented an overview of the forthcoming Hydrogeology Journal Special Issue: *Advances in hydrogeologic understanding of Australia's Great Artesian Basin.* Mr Craig Walton presented an overview of the regulation of the Great Artesian Basin, including the ongoing capping and piping program to cease uncontrolled flow of bores in the basin. Each presentation concluded with an independently derived summary of future research needs, which were well aligned.

Research needs (Carlos)	Research needs (Craig)
Water balance of individual aquifers and the sub-basins of the GAB	**Water balance, recharge and discharge** processes (land management impacts, climate change, rates of inflow, impacts of bore capping)
Spatial and temporal variability in **recharge and discharge** processes	**Communication / engagement** with open data (report cards, myth busting, bore monitoring)
How to use emerging knowledge to construct applicable **communication and decision tools**	The depth, scale and remoteness of the basins (monitoring technologies for bores and springs, lower risk and travel technologies)

The audience participated in a process to prioritise a list of questions which were then discussed by the panel.

Questions are in italics and the following notes reflect panel discussion and input from audience members.

1. *Oil and gas exploration and production within and from beneath the GAB has vastly increased our understanding of the Surat Basin and the Eromanga above Cooper Basin. How do we get additional detail in areas where oil companies are not paying for data collection?*

Points made included:

- We need to develop ways to upscale from areas where we have good data.
- More research is needed into the use of geophysical techniques which can be applied in data poor areas and calibrated against real data.
- We should look at opportunities for the community to collect data and contribute to a shared data resource.
- We need to identify where we need the data and who is responsible for that data collection and explore use of new technologies.
- We need both data collection and modelling.
- We need new data methods e.g. remote sensing, but we still need data at depth.
- Citizen science projects are good, but it's important to set these up in critical/priority areas so that we are gathering the data that is going to provide most value.
- Modelling may help to identify the areas where new data is needed.

2. *Citizen science can help with engagement, education and appreciation of our water resources, in addition to providing additional data. What further opportunities do you see for citizen science in groundwater and the GAB?*

   Points made included:

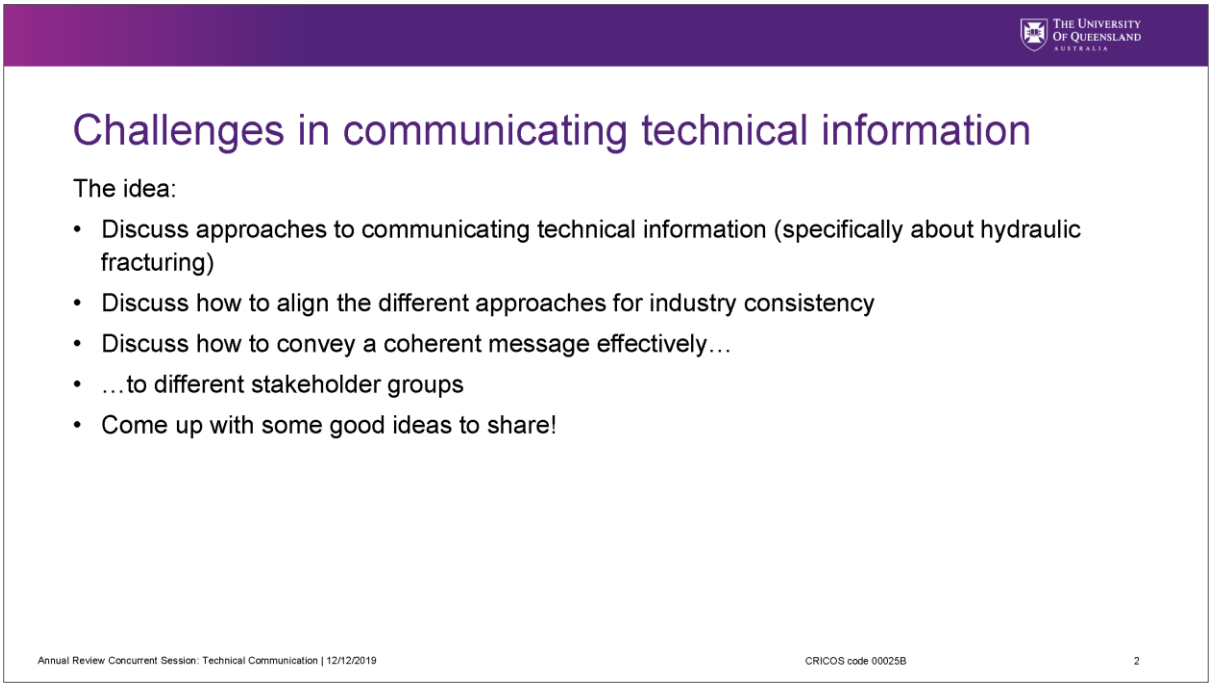
   - Citizen science projects are important, but they require good management and are not a trivial exercise.
   - It can be difficult to get stakeholder input to projects, even when there is a good level of understanding that the issue is important. Consultants working on a survey of the condition of uncontrolled water bores only achieved a 35% return rate to their surveys. Information from the capping and piping applications was used to validate and supplement the survey data.
   - These projects work well when people want to solve a problem and can see a benefit in it for themselves.
   - There are limits on the types of projects that can use these approaches – the level of technical complexity is a key issue.
   - It would be good to set these types of projects up in advance of any changes. This helps to gather baseline data, but importantly also builds knowledge and understanding amongst participants.
   - An issue is informing people about why they should be interested in helping. It's important to provide the right information and put the information and project in the right context.
   - Citizen science projects provide big value in terms of engagement and education.
   - We need processes to capture local knowledge from long-term landholders and people who maintain bores (pump maintenance experts) as they have detailed insights from their long experience – it's important to capture this history. We need to record both oral histories and technical data to get the full picture.

3. *Are we seeing changes in water quality at the same time as changes in pressure and flow?*
    - Recent investigations into catchments across the GAB have shown that there is a lot less groundwater extraction than previously.
    - No articles in the Special Issue looked at changes in water quality.
    - Experience in other areas e.g. the Thames River (NZ), has shown that there can be decades of delay between changes in land management practices and changes in groundwater quality.
    - We don't have enough data on water quality to make a scientific assessment. However, there it is likely that water bores with poor construction standards would impact water quality.

4. *The Queensland GAB shares state borders with the NT, NSW and SA. What transboundary issues are there in GAB management and is there potential for a Murray-Darling style issue to develop?*
    - Transboundary issues are not as great for the GAB as they are for the Murray-Darling Basin. There is an issue between Queensland and South Australia as both have a gas industry, but South Australia's groundwater extraction is much less than Queensland's overall.
    - The Basin states have a good relationship and talk to each other regarding management issues. This helps to avoid problems being created.
    - Ideally state governments should be discussing potential impacts of any new emerging industries before they actually get established.
    - Each State undertakes modelling of the GAB for various purposes – we need to make sure that these models are compatible. This means that good technical communication regarding modelling methods and data inputs is needed.

3 Appendices

3.1 Appendix A: Presentation Deck – Technical communications workshop



UQ Poll **Contribute here:** apps.elearning.uq.edu.au/poll/60575

ENGY101 Communicating Technical Information 101: What is the purpose of communication?

Question 1:

What is your main purpose for communicating technical information?

Answers:

A. To educate or inform the public
B. To influence opinions/behaviour
C. To defend or advance industry goals/operations
D. To build trust/support
E. To diffuse opposition

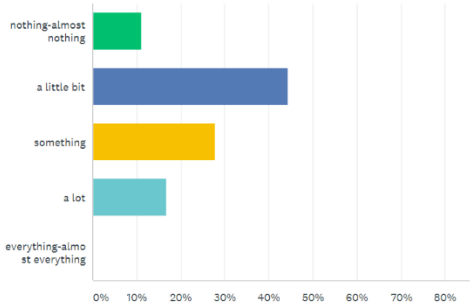
Some questions….

1. What do people already know about 'fracking'?
2. Where did they get their information from?
3. Do they want to be more informed?
4. What do they want to know more about?
5. Would being better informed change their opinion?

Some answers!

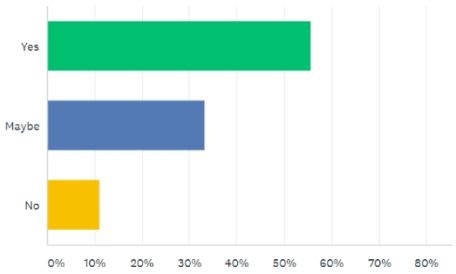
How much would you say you know about fracking?

Answered: 18 Skipped: 0



Are you interested in knowing more about fracking?

Answered: 18 Skipped: 0

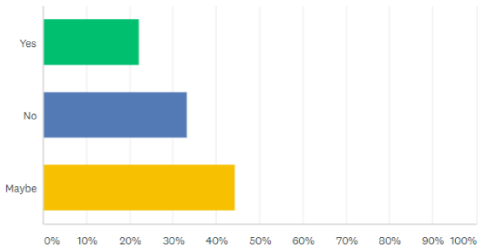


Disclaimer: This is not scientific research.
I acknowledge my Facebook friends who helped me out.

Would knowing more change opinions?

Do you think knowing more about fracking could make you change your mind about it?

Answered: 18 Skipped: 0



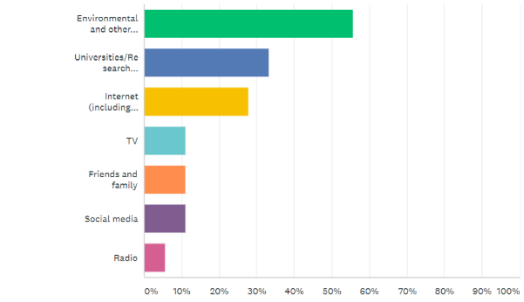
Disclaimer: This is not scientific research.
I acknowledge my Facebook friends who helped me out.

Maybe, but probably not.

Information appetites

Where did the information you have about fracking mostly come from?

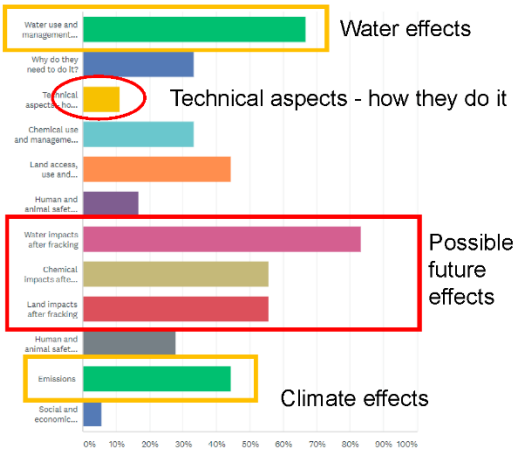
Answered: 18 Skipped: 0



Disclaimer: This is not scientific research. I acknowledge my Facebook friends who helped me out. There are studies on attitudes to fracking.

What aspects of fracking are you most concerned about or would like to know more about? Tick as many as you like.

Answered: 18 Skipped: 0



Water effects

Technical aspects - how they do it

Possible future effects

Climate effects

Responses reflect increasingly powerful discourses

Where do our emissions come from?

The Australian Government tracks our emissions of greenhouse gases (such as carbon dioxide and methane) through National Greenhouse Gas Accounts. The Department of the Environment and Energy publishes regular Quarterly Updates on Australia's greenhouse gas emissions.

According to the most recent Quarterly Update, issued in May this year, Australia produced 535.7 million tonnes of carbon dioxide equivalent (Mt CO_2-e) emissions. These emissions came from various sectors:

- **Energy (Electricity)**—187.5 Mt CO_2-e (or 35% of the total emissions) were produced by fuel combustion to make electricity (on- and off-grid).
- **Energy (Direct combustion)**—94.5 Mt CO_2-e (18%) were produced by fuel combustion directly used in energy, mining, manufacturing, buildings and primary industries. Direct combustion excludes electricity use and transport.
- **Transport**—93 Mt CO_2-e (17%) came from fuel combustion used in road, rail, domestic shipping and aviation, off-road recreational vehicles and pipeline transport.
- **Agriculture**—68.5 Mt CO_2-e (13%) were produced from livestock (approximately 70% of agricultural emissions), application of fertilisers and soil additives, soil emissions and burning of agricultural residues.
- **Fugitive emissions**—39.6 Mt CO_2-e (7%) were produced from fugitive gas emissions from coal, natural gas and oil extraction, processing and supply. Fugitive emissions can be unintentional (for example, a leak) or intentional (such as the burning of waste gases). The main source is coal mines (66%), with underground coal mines producing more than surface mines.
- **Industrial processes**—33.7 Mt CO_2-e (6%) were produced from industrial and production processes that do not create energy. This includes metal production, chemical industry processes and synthetic gas production and use (for example, hydrofluorocarbons).

https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/BriefingBook45p/EmissionsReduction

How 16-year-old Greta Thunberg became the face of climate-change activism

https://www.businessinsider.com.au/greta-thunberg-bio-climate-change-activist-2019-9?r=US&IR=T

EXTINCTION REBELLION

Activists end week of climate protests by shutting down Brisbane bridge

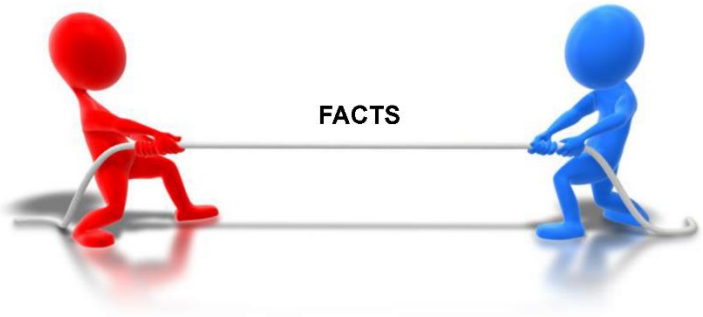
https://www.brisbanetimes.com.au/national/queensland/extinction-rebellion-plans-two-disruptive-brisbane-protests-this-week-20191206-p53hla.html

https://www.unwater.org/water-facts/human-rights/

Does communicating technical information help?

Values driven

Technical information contentious - resisted and opposed



A "call to action" – The Sustainable Development Goals

- A "blue print to achieve a better future"-
- The world's plan of action
- Set of shared global values

(Source: http://www.globalgoals.org/)

Businesses and industries across the world aligning themselves with SDGs

Clearly articulate their contribution and actions to enhance or mitigate- now and into the future

Transition to low carbon and the role of natural gas

Mining and other industries urged to contribute (and do)

"The 17 sustainable development goals (SDGs) (and 169 targets) to transform our world":

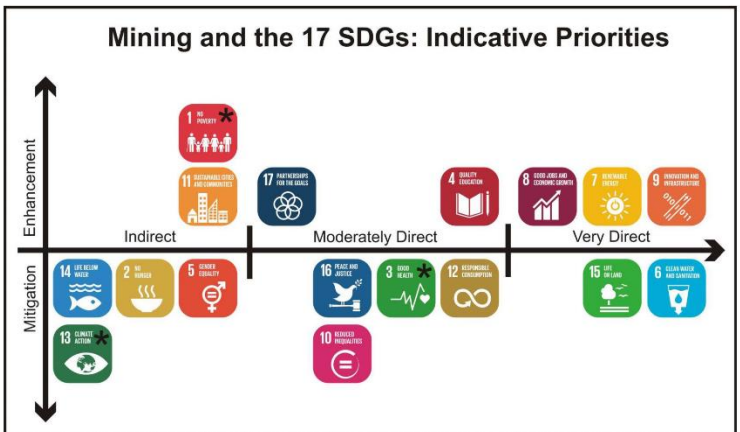


Figure 2: Indicative prioritization of SDGs for mining companies globally based on aggregating, for each goal, the relevance of each of its targets to mining. Individual cases may deviate from this categorization. Three horizontal categories = degree of impact mining has on goal: very direct, moderately direct, and indirect. Within each category, the farther right a goal is, the greater the impact mining has on its accomplishment. Two vertical categories = predominant focus for making positive impact (enhancement of positive impacts; mitigation of negative impacts). *Asterisked icons in practice have greater relevance for mining than the scoring suggests. Icons modified from http://www.globalgoals.org/.

Source: UNDP nd. 'Mining and the 17 SDGs' http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Integrating%20Environment%20into%20Development/mining-sdgs.pdf

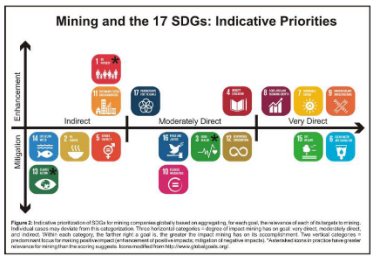
11

Mapping the Natural Gas industry to SDGs

Groups Exercise

Step 1: Sort the SDGs into most directly relevant – where does the gas industry have the greatest impacts?

*Make a note of why/ why not



Now we want to do more.

Our aspiration is to manage an organic beef supply chain that meets targets set by the UN Sustainable Development Goals.

This year, we have completely re-thought our sustainability strategy to focus it entirely on contributing to the UN Sustainable Development Goals (SDGs). Specifically, our targets for the topics we have identified as being material are now the relevant SDG targets. Our previous sustainability targets have been based on what we think is right. By replacing these with the SDG targets, we're now aiming for what the global community says needs to be done.

This is a big shift, and not without challenges. We are a small company sourcing cattle from a geographically vast supply chain and selling organic beef around the world. We have varying degrees of influence but no control along our supply chain.

The SDGs are our aspirational targets. We will use them to guide how to further reduce impact and increase value right along our supply chain in ways that encourage us to play our part towards achieving a better future for all.

Our pillars	ENVIRONMENT	PEOPLE	PRODUCT	ANIMALS
SDGs we aim to meet	6, 13, 15	2, 5, 8, 10	12	Not an SDG.

https://www.obeorganic.com/wp-content/uploads/2019-Sustainability-Report-1.pdf

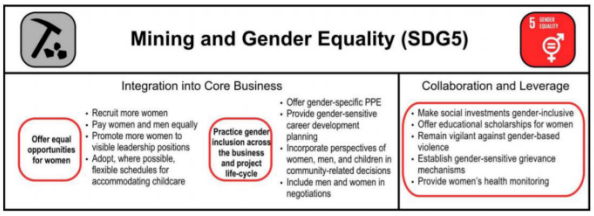
Mapping the Natural Gas industry to SDGs

Groups Exercise

Step 2: Starting with most directly relevant,

A. Discuss (and write down) how the industry enhances positive impacts and mitigates negative impacts towards achieving the goal

B. Discuss what opportunities there may be for collaboration and leverage (see the example document)



Step 3: Reporting out. What did you think? Share your discussions

Revisiting the role of technical information

- Changing expectations of businesses and industry – environmental and social responsibility
- More important among younger people
- SDGs as opportunities, as drivers of investment and support
- Communicating technical information is still important (particularly for key stakeholder groups) but should be located within in the context of broader societal goals and aspirations.

> *"Technology has great potential to help deliver the SDGs, but it can also be at the root of exclusion and inequality. We need to harness the benefits of advanced technologies for all".*
>
> - UN Secretary-General, Antonio Guterres, at the closing of the 2018 High-level Political Forum on Sustainable Development

3.2 Appendix B: Presentation Deck – When is an aquifer not an aquifer

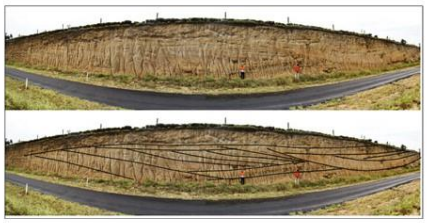
Walloons Springbok interface when is an aquifer not an aquifer?

Historically: The "Springbok" started as a Springbok "lens" in outcrop

The Springbok Sandstone is not predominately sandstone!

Any formation identification and correlative model which consistently "connects" base-sand to base-sand in his environment is not consistent with the spatial variability of depositional environment.

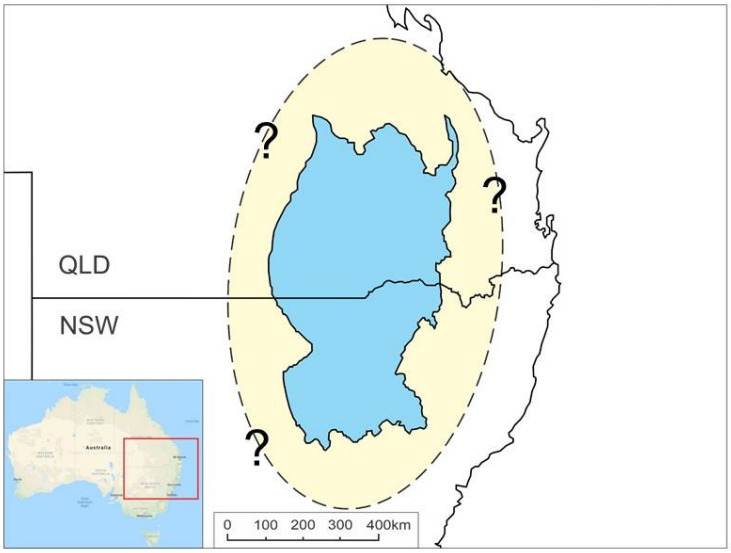
Arguably, the siltiest sequences (MFS equiv.) should be most aerially consistent/ correlatable. Significant for flow modelling.



Source: QGC 2012

New Acland outcrop

Surat Basin extent and modern coal forming depositional environments



Mississippi Delta
(fluvial dominated)

Ganges-Brahmaputra Delta
(tide dominated)

Nile Delta
(wave dominated)

Challenges – Heterogeneity Walloons/Springbok Section

- Both formations have very heterogeneous lithology
- Green (1997) described the lithology of the Springbok Sandstone:

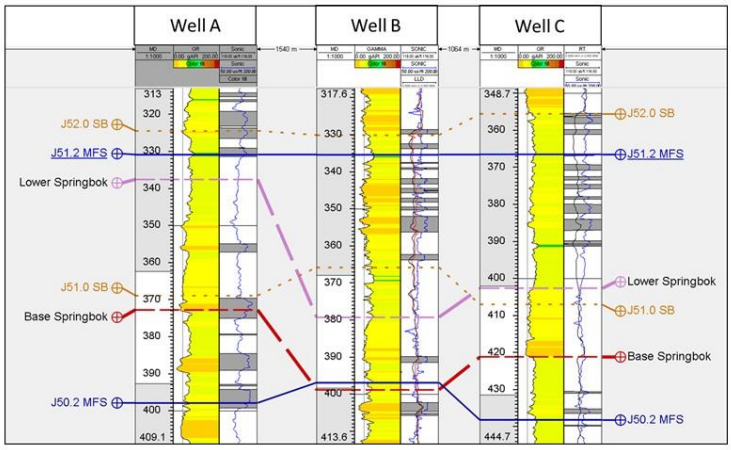
  *"The **sandstones** are very fine to coarse-grained, although some very coarse-grained poorly sorted, pebbly beds also occur. Minor interbedded **siltstones** and **mudstones** and thin **coal** seams are also present…"*

- And the Walloon Coal Measures:

  *"…very fine to medium-grained, labile, argillaceous **sandstone**, **siltstone**, **mudstone** and **coal**, with minor calcareous sandstone, impure limestone and ironstone"*

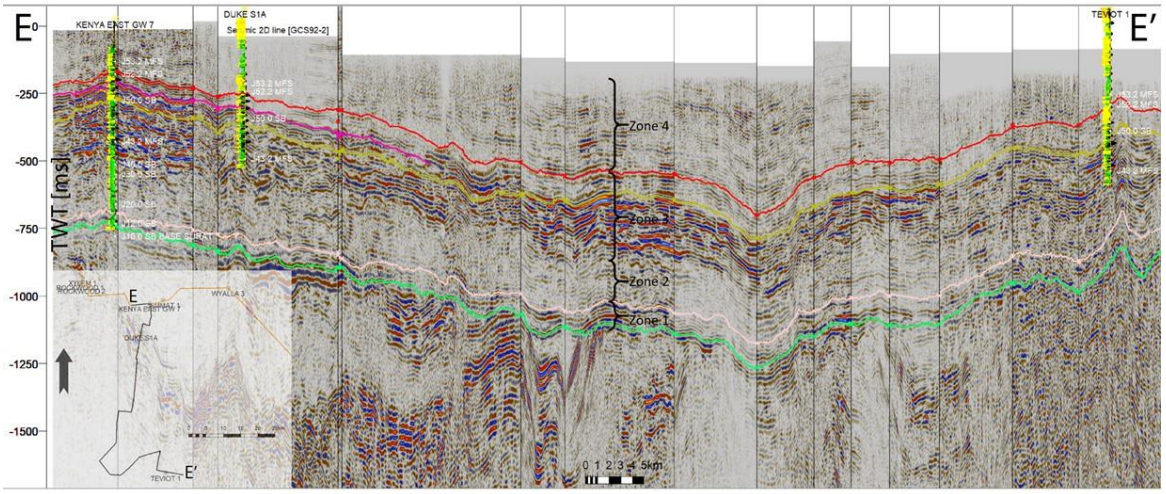
- Ironically, the Springbok Sandstone is **not** predominantly sandstone and the Walloon Coal Measures are **not** predominantly coal.

Impacts on Correlation

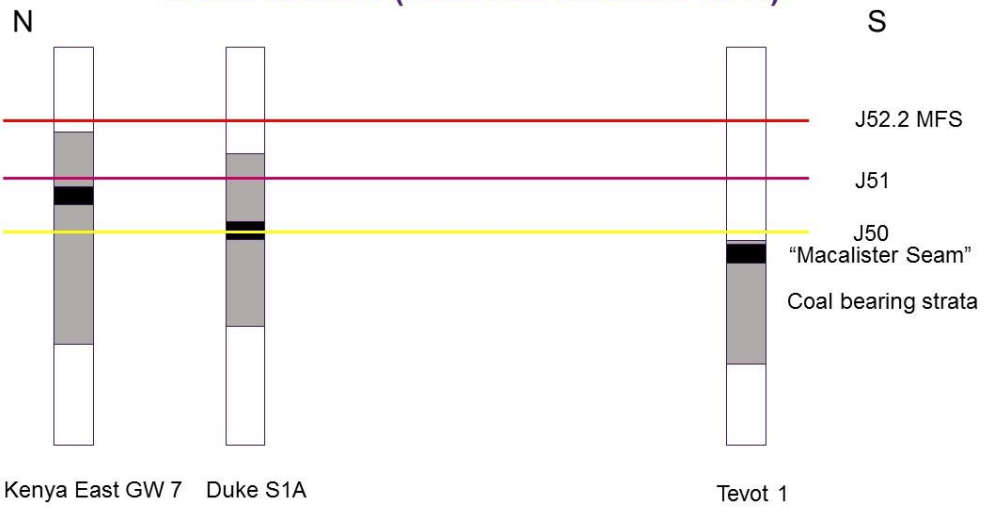


- J51.0 sequence boundary identified using sequence stratigraphy (log & core) **and** seismic.
- Sequence stratigraphy is based on identifying vertical cyclic sedimentation patterns, or sequences, bounded by discontinuities.
- Allows time equivalent intervals to be correlated between wells.
- "Sands" highlighted in red are correlated (lithologically) as "Springbok" but lie on different sides of J51.0 and are therefore not time equivalent.

Seismic cross section from Kenya East GW7 to Teviot 1 (Central Eastern Surat Basin)



Simplified sketch of the Kenya East GW7 to Teviot 1 seismic cross section (flattened on J52.2 MFS)



Why Does it Matter?

- 1,000s of CSG wells pass through the Springbok Sandstone
- Wells are designed to isolate the (historic) Springbok Sandstone, since it is an "aquifer"… or perhaps to isolate aquifer grade *sandstones*, within the Springbok *Sandstone* (where these sandstones are depositionally expected to be discontinuous and may be mis-indentified on logs).
- Alternative interpretations (e.g. previous slide) could "move" coals in or out of the Walloons or Springbok *(although this may simply be an issue with nomenclature… it doesn't change the actual geology!)*
- This could mean:
    1. Potentially productive coals need to be isolated, and cannot be produced → Lost reserves
    2. CSG wells that have already been drilled are now considered to be producing from the Springbok not the Walloons → May lead to concern from Springbok water users
- Another impact of inconsistent, or incorrect, correlations relates to flow modelling.

Why Does it Matter?

- Heterogeneity and challenges identifying lithology in wireline logs makes picking the boundary between the Springbok Sandstone and Walloon Coal Measures difficult.
- Correlation of this boundary can have impacts on:
    - **Reserves**, by moving coal into or out of the Walloons or Springbok
    - **Stakeholder concerns** regarding Springbok extraction
    - **Modelling**, particularly in systems with layers that have large contrasts in hydraulic conductivity, or high vertical anisotropy for hydraulic conductivity (both occur in the Springbok/Walloons)
- An updated, integrated approach to stratigraphy, including aspects of both sequence (chrono-) stratigraphy and lithostratigraphy, could produce better predictive models and yield both better environmental and reserves outcomes.

Definitions Aquifer

GA:
Groundwater is found in aquifers which are geological formations able to store and transmit water.

USGS:
When a water-bearing rock readily transmits water to wells and springs, it is called an aquifer.

Cambridge Dictionary:
A layer of rock, sand or earth that contains water or allow water to pass through it.

3.3 Appendix C: Presentation Deck – Great Artesian Basins (overview)

SI – Advances in hydrogeologic understanding of Australia's Great Artesian Basin

GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Affiliation	Count
Arrow Energy	3
Bureau of Meteorology/University Melbourne	1
CSIRO	3
DNRME	1
GA	1
Griffith University	1
KCB	1
OGIA	3
QUT	1
University Melbourne	2
Former GA	1
OSU/Flinders University	1
DEW/Flinders University	1
ANSTO/Flinders University	1
The University of Texas at Austin/Flinders University	1
The University of Queensland	4
Grand Total	**26**

Article type	Count
History of the GAB	1
Eminent researcher	1
Groundwater flow processes (conceptualisation)	6
Groundwater flow processes (faults conceptualisation)	2
Groundwater flow processes (modelling)	2
Groundwater flow processes (recharge)	2
Springs and GDEs	6
Groundwater Governance	6
Grand Total	**26**

12 papers available online (and counting) as of 10 Dec 2019

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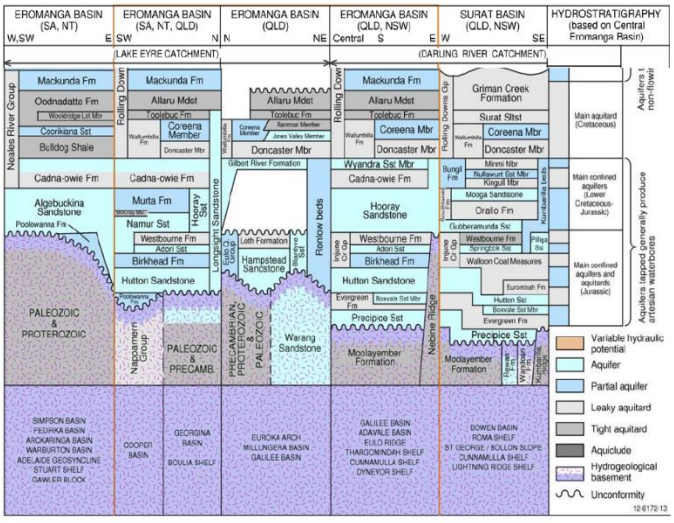
GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Geological heterogeneity and consequent **complexity** are high across **different scales**, from **boreholes** to the **whole of the GAB**.

Implications:

- **Hydrogeological conceptualization**
- how to develop **new representations** of **flow systems** in **numerical models**
- how we should **interpret water level** and **hydrochemistry data differently**
- conceptualize **lateral heterogeneity** in areas with **sparse data** from what we've learned from the **Surat Basin** (e.g. low energy lacustrine deposition environments)



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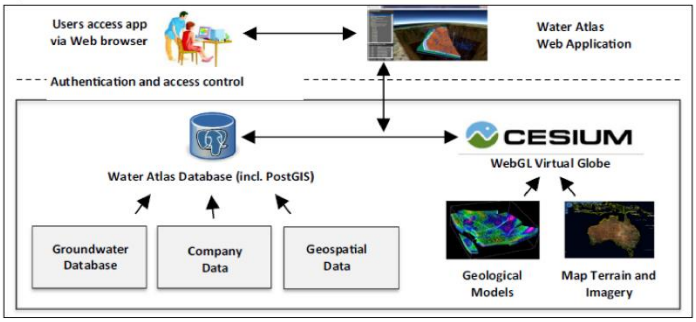
GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Ever-increasing density, resolution and extent of data:

- **Surat Basin** - **petroleum-industry** investigation methods of **high-resolution downhole and surface geophysics, laboratory core analysis** and **advanced isotopic** methods
- **satellite** and other **geophysics** data, the increasing role of **big data management and visualization**, and initiatives to **turn big data into better conceptual and numerical models**



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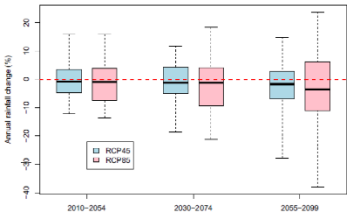
GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Recharge processes are complex and space and time dependent:

- **How much** water currently recharges GAB aquifers and **how much is lost** in surface and **shallow subsurface processes**?
- Over **what time scales** are we required to consider, what is the **spatial distribution of the recharge**, and how is this influenced by climate change?
- 2 papers **challenge traditional understandings** or recharge processes by showing **most recharge is lost in shallow processes** – localised examples

Climate-change impacts on the GAB region, with a focus on **spatio-temporal evolution of recharge**, but also with valuable information for **future water availability** for **water-resources planning**



Fu et al.

Aquifer	Baseline recharge (mm)	Climate scenario (change in recharge)		
		Dry	Median	Wet
Adori SpringBok Aquifer Outcrop	26	−41%	−4%	45%
Cadna-owie–Hooray Aquifer Outcrop	49	−29%	3%	50%
Hutton Aquifer and Equivalents Outcrop	35	−35%	−1%	46%
Precipice Aquifer and Equivalents Outcrop	52	−35%	1%	51%

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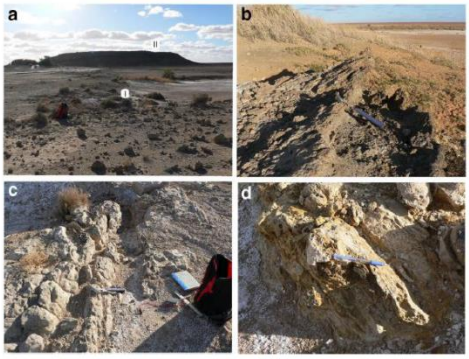
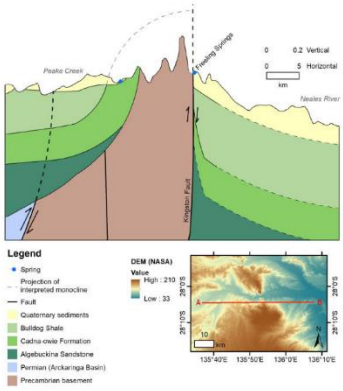
GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Discharge processes are complex and important:

- springs and associated GDEs
- understanding of discharge processes at springs
- role of structure in controlling discharge locations
- quantification of deep artesian waters versus locally-derived recharge in spring flow
- Diffuse recharge (e.g. Eromanga Basin)





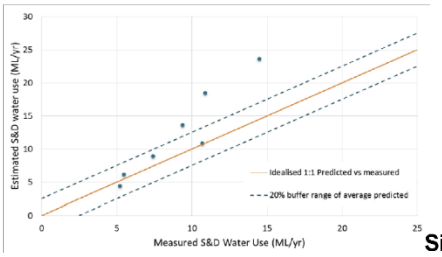
Keppel et al.

SI – Advances in hydrogeologic understanding of Australia's Great Artesian Basin

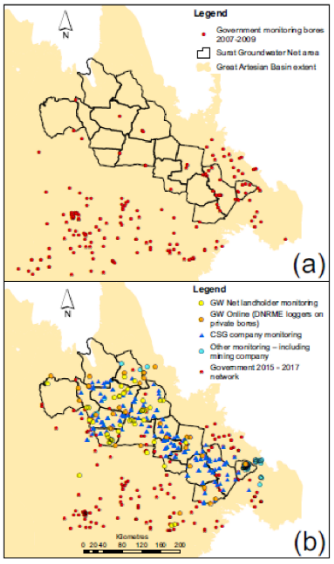
GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Examples of effective participatory models for better management, including water-governance analyses, perception and acceptance of new technologies, and citizen science are given in the Special Issue.

Two articles proposed improved methodologies for estimating groundwater abstraction, highlighting uncertainties that can be addressed with further targeted metering.



Singh et al.



Jamieson et al.

SI – Advances in hydrogeologic understanding of Australia's Great Artesian Basin

GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Despite the advances, there are still significant gaps in knowledge:

- water balance of individual aquifers and the sub-basins of the GAB
- spatial and temporal variability in recharge and discharge processes
- how to use this knowledge to construct applicable communication and decision tools

It is critical for **multiple stakeholder groups**, **government agencies**, **States**, **GAB-CC** and **new collaborative research programs** involved in GAB management and study to ensure **knowledge-improving efforts are effectively integrated and consolidated**

Renewed efforts at a **GAB-wide numerical model** might be a **way forward for integrating new knowledge** and **data collected** as shown in this **Special Issue**

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Summary of Advances

- **Geological heterogeneity** and consequent **complexity** are high across **different scales**, from **boreholes** to the **whole of the GAB**
- Ever-increasing **density**, **resolution** and **extent of data**
- **Recharge** processes are **complex** and **space and time dependent** – **new conceptual models** emerging
- **Discharge processes** are **complex** and important
- effective **participatory models for better management**, including **water-governance analyses**, **perception** and **acceptance of new technologies**, and **citizen science**
- **estimating groundwater abstraction**, **uncertainties** can be addressed with further targeted **metering** – **new technologies** and **participatory models**
- Renewed efforts at a **GAB-wide numerical model** might be a way forward for **integrating new knowledge and data collected** as shown in this Special Issue

CRICOS code 00025B

THE PROJECT

GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

July 2018 – Oct 2019	24-27 Nov 2019	Jan/Feb 2020	Jan – July 2020
Produce a comprehensive peer reviewed evidence base	**Launch** at Groundwater conference	**Publish** findings in Hydrogeology Journal	**Promote** Findings to relevant stakeholders

- To inform public, planning and policy for resource projects affecting the Great Artesian Basin Aquifers.
- The key industry scientific journal of the International Association of Hydrogeologists (IAH).
- Using a program of targeted engagement activities and producing easily accessible educational and information material.

GREAT ARTESIAN BASIN BODY OF KNOWLEDGE

Thank you

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CRICOS code: 00025B

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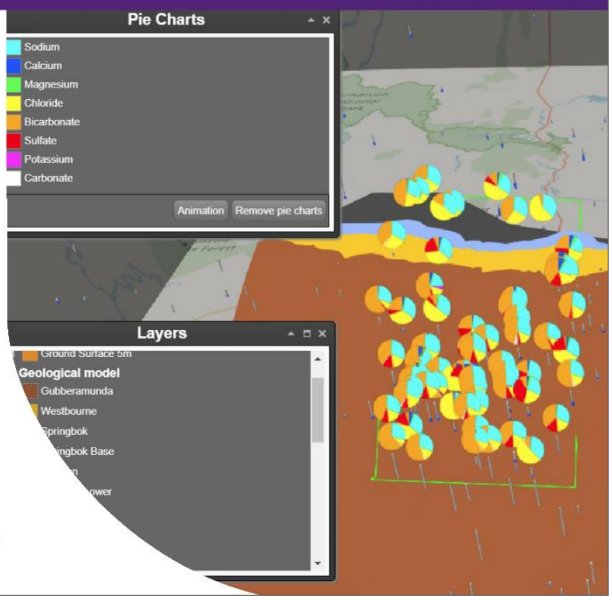
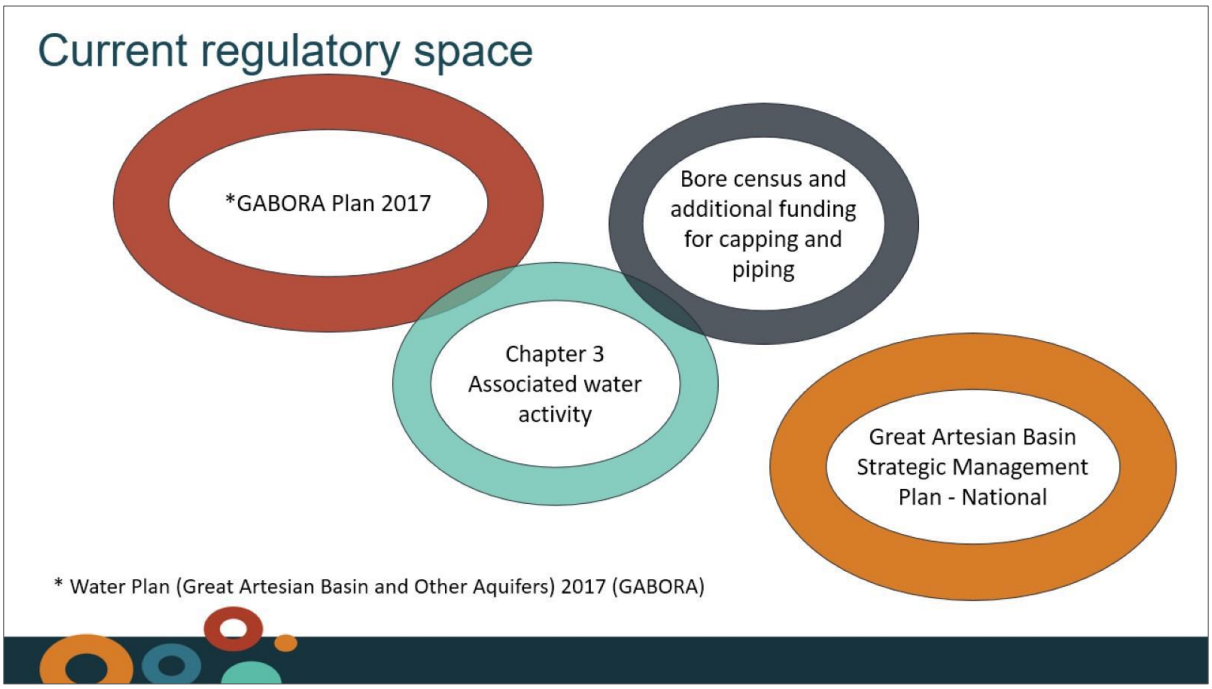


3.4 Appendix D: Presentation Deck – Great Artesian Basins (regulatory aspects)



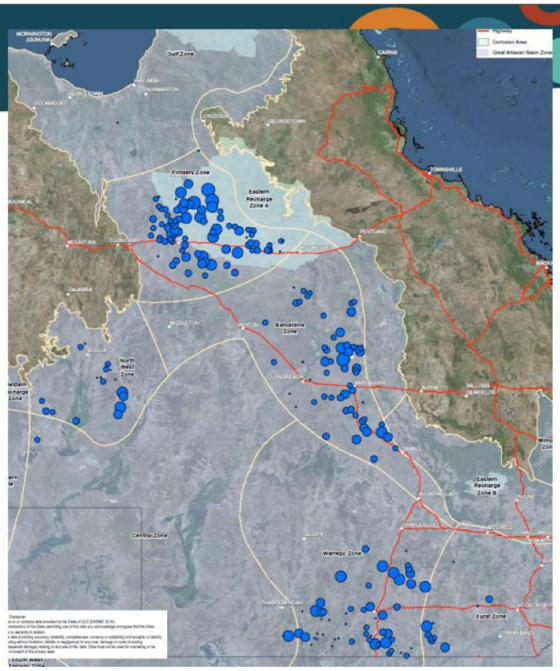
Bore census

GAB Bore Census

- 179 uncontrolled bores [20%]
- 3,986km bore drains to be piped [22%]
  - (assoc. 377 bores)
- 412 controlled bores
  - (137 watertight – i.e. capped & piped)
- 30 plugged bores
- 223 ceased to flow bores
- 6 unknown condition

- Total water saving - 89,296ML [30%]

Total cost - $128 million



Strategic Management Plan 2000-2015

- First 'whole-of-Basin' management plan adopted by all governments responsible for GAB management
  - Behavioral change towards water efficiency
  - New partnerships between governments, industry and communities
  - Development of state water planning with community consultation and advisory bodies
  - Cross-border cooperation and collaboration by Basin governments
  - Increased focus on the GAB springs

SMP 2019-2034 : Guiding Principles 6-7

Information, knowledge and understanding	Information management, communications and education
Information, knowledge and understanding for good management means that accurate, timely and readily accessible information supports good management of the Great Artesian Basin.	Information management, communication and education means that water resource management information, including information on social, cultural, economic and environmental values, will be publicly available, easily accessible and clearly understandable

Strategic Management Plan 2019

Policy related research

- Communication / engagement with open data
  [report cards, myth busting, bore monitoring]
- Water balance, recharge and discharge processes
  [land management impacts, climate change, rates of inflow, impacts of GABSI programs]
- The depth, scale and remoteness of the basin(s)
  [monitoring technologies for bores and springs, lower risk and travel technologies]

Next steps

Already underway

- Geoscience Australia GAB water balance project - $6.5 M
- GAB to be include in the National Water Account – BOM - $250K
- Spring surface best practice management

Proposed

- Information and knowledge gaps strategy 2020-2025 - early 2020
- National call for IGABDR funded research projects - late 2020-21

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CREATE CHANGE