Brisbane

Level 11, 116 Adelaide St
Brisbane QLD 4000

PO Box 12052
George St QLD 4003

p: +61 7 3231 0500
e: brisbane@appea.com.au
w: www.appea.com.au

21 August 2020

National Water Reform 2020
Productivity Commission
water.reform.2020@pc.gov.au

Dear Sir/Madam,

RE: National Water Reform 2020

I am writing to provide the Australian Petroleum Production and Exploration Association's (APPEA's) submission to the above issues paper released by the Productivity Commission in May 2020.

APPEA is the peak body representing Australia's oil and gas explorers and producers. Our members account for nearly all of Australia's oil and gas exploration and production.

The oil and gas industry is a vital part of the Australian economy:

- Oil is the largest primary energy source in Australia providing nearly 39% of all energy consumed.
- Natural gas is a major energy source to nearly 70 per cent of Australian homes
- Natural gas is an essential input to the manufacturing sector, underpinning more than 225,000 jobs
- The oil and gas industry invested more than $350 billion over the last decade in developing new supply for domestic and export customers
- The oil and gas industry pays $5.8 billion in taxes and resource charges to governments, employs around 80,000 Australians in highly skilled, highly paid jobs, generates $47 billion in export earnings; and accounts for more than 2% of GDP.

Water is one of Australia's most precious assets. Industry recognises its responsibilities to protect that natural asset for other users today and for future generations.

The industry's use of water is relatively modest – less than 0.2 per cent of the water consumed by Australians (by comparison, agriculture accounts for almost 59 per cent of national water consumption).

In the case of Queensland coal seam gas projects, the industry has a legislative right to produce water for the purpose of petroleum production. This right is distinct from other water users who access water under different arrangements, but with the right comes special responsibilities that are not applied to other water users. The result is Queensland's gas industry is more of a supplier than a consumptive user of water. Most water removed from coal seams as a by-product of gas production is treated and provided free or at low cost to other users such as farmers and local government or used to recharge aquifers. Industry in Queensland has invested more than $3 billion in water treatment infrastructure, and almost all of the 66 GL produced by the industry is treated to meet strict water quality standards and beneficially reused[1]. The largest beneficial use is irrigation for farming, and about one-quarter of the water removed from local coal seams is returned to aquifers.

The oil and gas industry delivers an exceptionally high economic return from the water it uses. According to the Australian Bureau of Statistics, the gas industry's value-add is $933m Gross Value Add per gigalitre of water used, compared to $4m for agriculture, $37m for aquaculture and $83m for wood, pulp and paper.

Regulatory regimes for water continue to evolve and adapt over time as information is collected. It is important that a refreshed National Water Initiative recognises:

1. the extensive regulation already in place for water use, management, and supply by the oil and gas industry
2. the different rights and responsibilities applied to the oil and gas industry that are designed to reflect the different operational context relative to other water users
3. the extensive monitoring and forecasting of water production and consumptive use by the oil and gas industry which is accounted for in government water management plans

The attachment to this letter provides further detail of how water is used, supplied, and managed by the oil and gas industry and how these activities are regulated.

Regards,

Matthew Paull
Queensland Policy Director

[1] https://gasfieldscommissionqld.org.au/shared-landscapes

ATTACHMENT

Water use, supply and management in the oil and gas industry

Contents

Key points:

- Petroleum is essential to the Australian economy and way of life. As well as generating $47 billion in export earnings the industry supplies an important energy and commodity resource. Natural gas is also an essential input for many manufacturing businesses.
- The petroleum industry is a minor user of water compared to other larger water users and represents a very high economic value-add to the Australian economy.
- The industry works collaboratively with all stakeholders to minimise any impacts of the oil and gas industry's use and take of water.
- Conservation and protection of groundwater and surface water is a high priority during all oil and gas activities.
- Safeguards are used to protect water resources at all stages of a petroleum project. Wells are constructed to a high standard and include multiple engineered barriers to ensure containment and isolation from geological formations.
- Surface water is protected by employing comprehensive water protection safeguards and risk controls. Studies and decades of practical experience show the risk to groundwater and surface water is low.
- The regulatory frameworks governing the oil and gas industry's use and impact on ground and surface water resources are comprehensive.
- State Governments are active managers of water resources. Ongoing and detailed regulatory reviews occur frequently and these enable the detailed consideration of all issues including social, economic, and environmental outcomes.
- The petroleum industry is subject to stringent regulation. The full range of potential impacts – environmental, social and economic – are assessed at local and regional levels to manage the resource safely and sustainably.

1. The social, economic and environmental impacts of extractive projects' take and use of water

- The petroleum industry uses water as a direct input to the process of producing petroleum.
- Developing these resources is vital to Australia. Petroleum products, from gasoline to plastics, are integral to our everyday lives.
- Petroleum is the raw feedstock for many chemical products, including pharmaceuticals, solvents, fertilizers and pesticides on which we rely.
- Australia's generates $47 billion in exports, oil provides 39% of all energy consumed, and natural gas provides ore than 25% of Australia's primary energy.
- The petroleum industry uses water efficiently, generating significant value add for the wider Australian economy.
- Further development of natural gas can have significant climate benefits, reducing emissions intensity.

Almost half of Australian homes – five million households – are connected to the natural gas network. In NSW and Victoria alone, 2.3 million homes are connected. Gas accounts for 44 per cent of household energy use, with more than 11 million residential gas appliances in use.[2]

Petroleum and refined and derived products are used to power our cars, to provide energy and support manufacturing. Oil is the largest single energy source in Australia and accounts for close to 40 per cent of total energy end use[3]. Australia's reserves of liquid fuels are declining, with an increasing proportion of these products being imported.

Natural gas is indispensable to many manufacturing processes. Gas is used to produce non-ferrous metals (such as aluminium, copper and zinc), chemicals and polymers (such as fertilisers and anti-freeze), plastics and non-metallic mineral products like glass, ceramics, cement and bricks, and is also used in food preparation, processing and packaging, fermentation and brewing.

APPEA estimates about 225,000 jobs in the manufacturing sector rely on natural gas. Manufacturing clusters dependent upon gas are found in all Australian states.

Until recently, the demand for natural gas has been met from 'conventional' gas reserves (for example, the Cooper, Gippsland and Carnarvon basins). However, in eastern Australia, production from these established conventional sources has peaked.

Fortunately, the last decade has seen a new and growing source of supply created – the coal seam gas reserves of Queensland. The potential of coal seam gas was identified in the 1990s. However, technical challenges and production costs higher than established conventional sources prevented its large-scale development. The opportunity to use coal seam gas as the feedstock for liquefied natural gas (LNG) exports changed the equation, drawing in an unprecedented $70 billion in investment to unlock the resource.

Today, Queensland's unconventional gas reserves are the largest sine source of natural gas in eastern Australia. More than half of the gas consumed on the east coast is coal seam gas from Queensland; almost 90 per cent of gas reserves on the east coast are unconventional gas.[4]

The LNG industry has not only created its own supply – it has created much of the new supply flowing into the domestic market.

Between 2011-2018 Queensland's oil and gas industry[5]:

- Accounted for more than $49.7 billion in direct spending in Queensland via business purchases, community and government payments
- Spent $23.6 billion in Queensland's regional areas
- Paid $4.9 billion in wages and salaries
- Directly employed 4,600 people (yearly average)
- Paid $505 million directly to landholders

[2] Deloitte Access Economics (2016), *Analysis for Gas Vision 2050.*
[3] Australian Government (2016), *Australian Energy Statistics* https://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/
[4] EnergyQuest (2017) *Energy Quarterly September 2017 Report*. http://www.energyquest.com.au
[5] Lawrence Consulting (2019) *Economic Impact of Queensland Petroleum & Gas Sector*, prepared for APPEA.

The industry has a relatively small physical ‘footprint’ which limits its impact on traditional rural industries. Access to land is negotiated under a regulatory framework which seeks to minimise impacts and ensures fair compensation for landowners.

Regional communities and other local industries are sharing the benefits of the infrastructure funded by the gas industry. For example, renewable energy projects are connecting to new power infrastructure built to serve gas projects. Farmers now have access to new supplies of treated water for irrigation, lifting productivity and farm incomes.

Outside Queensland, unconventional gas production is in its infancy, largely because of regulatory restrictions. While most of New South Wales is effectively closed to development, the one project seeking approval from the State government - Santos’s Narrabri project - could supply 50 per cent of the state’s gas demand. The Northern Territory has major unconventional resources. Victoria has significant natural gas potential with up to 27 TCF (28,514 PJ) of unconventional gas in the onshore Gippsland and Otway basins. Western Australia and South Australia also have promising resources which could underwrite significant industrial development.

1.1.1. Essential for Australian manufacturing

Natural gas is both a source of energy and an essential raw material (feedstock) for manufacturing. Almost one-third of the gas consumed in Australia is used by manufacturers.

About 225,000 people work in manufacturing sectors that rely heavily on gas; another 500,000 people work in related industries. The main industrial uses of natural gas and gas-derived products are producing:

- non-ferrous metals (e.g. aluminium, copper, zinc, tin)
- chemicals and polymers (e.g. fertilisers, antifreeze)
- non-metallic mineral products (e.g. glass, ceramics, cement, bricks)
- plastic packaging for foods and beverages.
- Gas is also needed in food preparation and processing, fermentation and brewing.

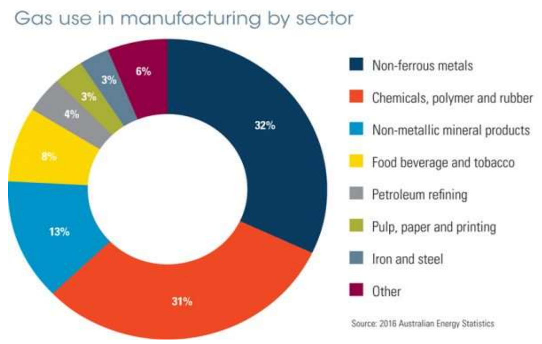

Figure 1 Gas — powering industrial processes

Gas is second only to oil as an energy source for manufacturing. Gas is essential for many industrial processes, especially processes requiring high temperatures — without gas to fire kilns and furnaces, it would be impossible to make everyday products such as glass, bricks, paper, cement, steel and alumina.

Gas — the invisible ingredient of everyday products

Natural gas is also a raw material (feedstock) for creating products such as fertilisers, explosives, paper, plastics and chemicals. In most cases, there is no substitute for gas. Gas is used to produce ammonia, which is an important feedstock for several industries.

The most commonly used fertiliser in the world is urea, which is produced from ammonia.

Producing each tonne of urea requires 21GJ of natural gas — the same amount of gas that the average NSW household uses in a year. Australian industries use 1.6 million tonnes of urea each year.

Ammonia is also used to make explosives and cleaning products, and in fermentation, brewing and winemaking.

The plastics used in food packaging, plumbing, guttering, fibres, textiles, machine parts and a host of other applications are made from ethane derived from natural gas.

1.1.2. Climate Benefit of Natural Gas

The International Energy Agency, the Climate Change Authority and most independent experts agree that the world will and should be using *more* gas in the transition to a low-emissions economy.

Gas-fired generation offers reliable, on-call and low emissions power. The emissions intensity of gas-fired plant can be as low as one-third of coal-fired plant. Experience in the United States shows how the substitution of gas-fired generation for coal-fired generation can slash emissions without jeopardising reliable, affordable supply. The US Energy Information Administration (EIA) reports that the shift to gas-fired generation accounts for 63 per cent of the 12 per cent reduction in U.S. energy-related CO_2 emissions during the last decade.[6] This shift has prevented 1.5 billion metric tons of carbon dioxide being emitted from power plants in the United States.

Australia has a similar opportunity to meet our energy needs while reducing emissions.

Gas-fired generation technologies can slash greenhouse gas emissions by 55 per cent compared to the National Electricity Market (NEM) average, and by 68 per cent compared to current brown coal generation technologies and 61 per cent compared to current black coal generation technologies[7].

The on-call nature of gas-fired generation means it is ideally suited to 'firm up' intermittent renewable energy as well as to respond to surges in electricity demand. International research shows that the increasing penetration of renewable energy in OECD countries between 1990 and 2013 has been facilitated by fast-reacting, gas-fired generation.[8]

Australians have seen how gas-fired generation underpins energy security. The Australian Energy Market Operator made this point clear. The 2017 Gas Statement of Opportunities begins with the

[6] U.S. Energy-Related Carbon Dioxide Emissions, (2015) https://www.eia.gov/environment/emissions/carbon/
[7] Commonwealth of Australia, (2016), *Preliminary Report of the Independent Review into the Future Security of the National Electricity Market*, , p.63, www.environment.gov.au/system/files/resources/97a4f50c-24ac-4fe5-b3e5-5f93066543a4/files/independent-review-national-elec-market-prelim.pdf
[8] Verdolini, Vona and Pop (2016), *Bridging the Gap: Do Fast Reacting Fossil Technologies Facilitate Renewable Energy Diffusion?* *http://www.nber.org/papers/w22454*

statement: *"Gas-powered generation is vital to continued security of electricity supply as the National Electricity Market transitions to lower emissions targets."*[9]

Numerous reports have shown that natural gas has a critical role to play in a low-emissions future as both a replacement for coal and a partner for renewables. For example:

- Modelling for the Climate Change Authority's August 2016 *Special Review on Australia's Climate Goals And Policies,* found under its preferred policy option that Australia must triple its use of gas in electricity generation by 2030 if we are to achieve our emissions reduction targets.[10]
- The December 2016 Preliminary Report of the Finkel Review stated: *"Gas has the potential to smooth the transition to a lower emissions electricity sector"* and *"The need for greater gas supplies for electricity generation is increasingly urgent."*[11]
- The May 2016 *Final Report of South Australia's Nuclear Fuel Cycle Royal Commission* highlighted the critical role of cleaner-burning natural gas in the low-carbon economy of the future, including as a partner for renewable energy. It found *"Gas-fired generation plays a significant role in providing reliable supply under all future low-carbon scenarios for the electricity sector."*
- The November 2015 *Australian Power Generation Technology Report* provided a thorough, independent assessment of renewable, coal and gas technologies. It found gas-fired generation is cleaner than coal, cheaper than renewables and can adapt quickly to meet changing demand.

1.1.3. Community Benefit

Regional communities benefit the most from the onshore industry, with new jobs and infrastructure creating stronger, diversified regional economies.

In places, such as the Western Downs, the resources sector (including the natural gas industry) has become the largest contributor to gross regional product. Research by the CSIRO and the Department of Industry, Innovation and Science confirms a very positive social dividend in regions which host the industry, including low unemployment, higher family incomes, a reversal of population decline, more employment opportunities for women and higher levels of youth education.[12]

The industry has always regarded the support of local communities and the informed consent of landholders as essential to the long-term partnerships that enable our activities to be successfully conducted.

Many reputable and independent studies have identified significant positive regional socio-economic benefits of onshore gas and resources production. Community attitudes to the industry have also

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[9] AEMO, (2017) 2017 Gas Statement of Opportunities (page 1) http://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/GSOO/2017/2017-Gas-Statement-of-Opportunities.pdf

[10] Climate Change Authority, special review on Australia's climate goals and policies (2016), http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/Special%20review%20Report%203/Climate%20Change%20Authority%20Special%20Review%20Report%20Three.pdf

[11] Dr Alan Finkle AO, Independent Review into the Future Security of the National Electricity Market, (2016) https://www.energy.gov.au/sites/g/files/net3411/f/independent-review-future-nem-prelim.pdf

[12] Office of the Chief Scientist, Department of Industry, Innovation and Science; GISERA (2015) *Review of the socioeconomic impacts of coal seam gas in Queensland.* https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/coal-seam-gas/Socioeconomic-impacts-of-coal-seam-gas-in-Queensland.pdf

generally been found to be positive. Research confirms that the resources industry is most supported in areas where it operates :

- The Australian Government's Bureau of Resource and Energy Economics (BREE) reported in 2015 that there are long term net economic benefits from CSG and negligible impacts of water and air quality to date.
- The CSIRO reported in 2013 that the CSG industry is contributing to poverty reduction, increasing employment and family income, and that there is a growing youth population in regions with CSG development.
- A 2013 study by KPMG showed that resources developments are not only making regions more prosperous, but also making their communities more stable and socially sustainable.
- A 2014 report by the CSIRO found that the majority of the community in Tara, Chinchilla, Miles, and Dalby accept, approve, or embraces the industry with only a small minority rejecting the industry:
- A 2018 social impact assessment for gas development in the Northern Territory found community concerns and threats can be mitigated and managed. They also identified significant opportunities for the enhancement of social values, such as collaboration between the community and industry, increased training and employment opportunities, better infrastructure, and indigenous participation.[13]

In addition to the broader socioeconomic benefits that come with increased economic activity and a more diverse regional economy, Queensland's natural gas and LNG industry has made significant public investments in the communities within which it operates. More than 220 different community organisations, based primarily in rural areas, received support from the industry.

1.2. Volume of Water used in oil and gas

The oil and gas industry uses very little water, relative to other industries.

During 2015-16, an estimated 76,544 gigalitres (GL) of water was extracted from the environment to support the Australian economy across all sectors. The main user of water is agriculture which consumed 9,604 gigalitres of water.[14]

The broad extractive industry sector (i.e. mining, mineral processing, oil and gas) accounted for about 4 per cent (661 gigalitres) of water use in 2015-16. The oil and gas industry used just 26 gigalitres or 0.16 per cent of total Australian water consumption (see Figure 3)

[13] Coffey (2018), Beetaloo sub-basin Social Impact Assessment Case Study https://frackinginquiry.nt.gov.au/inquiry-reports?a=476739

[14] Australian Bureau of Statistics, (2017) *4610.0 Water Account 2015-16.* www.abs.gov.au

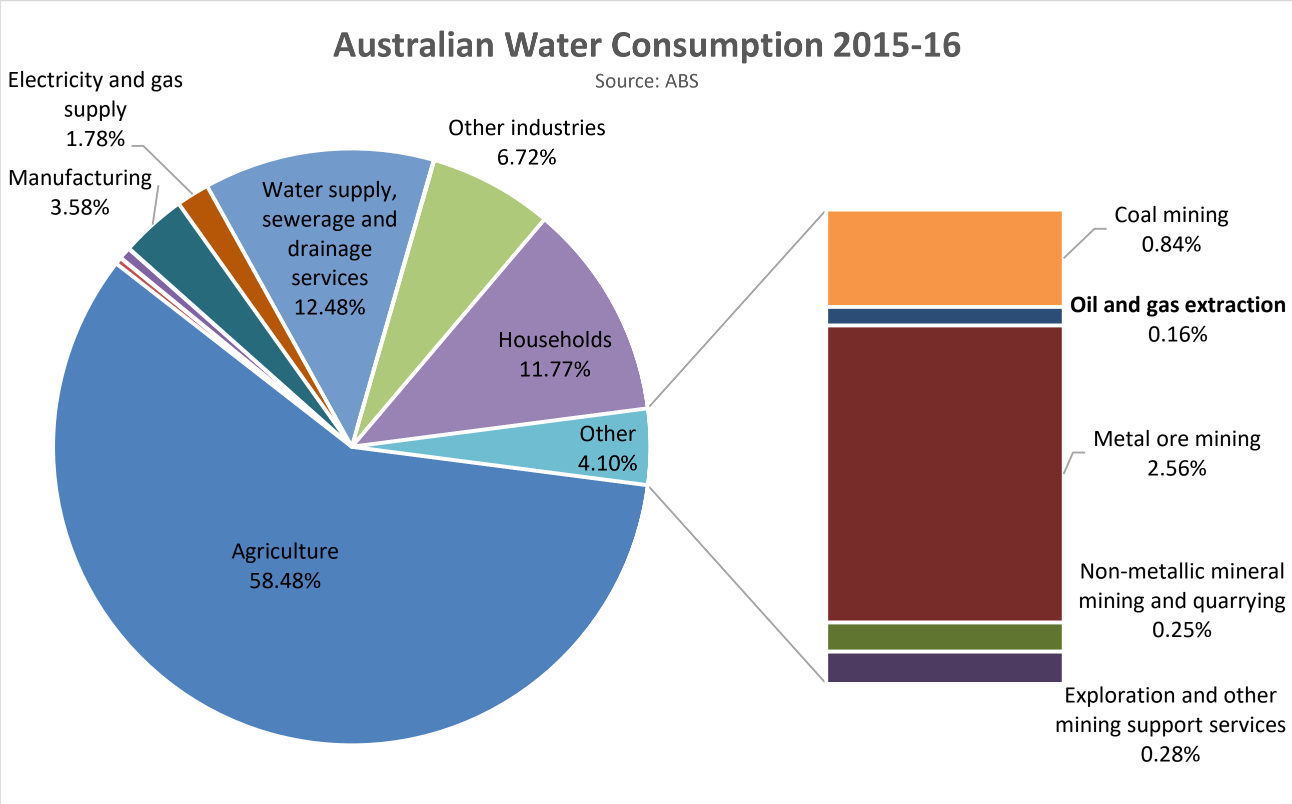

Figure 2 Water consumption by Industry and Disaggregated Mining Sector, 2015-16 (%).

1.3. High economic value of water use

The water used by the oil and gas industry generates an exceptionally high economic value-add.

Value added measures the value of the end product compared to the water used in its production - calculated as millions of dollars per gigalitre of water. According to the Australian Bureau of Statistics, every gigalitre of water consumed by the oil and gas industry generates over $933 million of value. This return is extremely high compared to other large water users; $127 million per gigalitre in coal mining, $37 million in aquaculture and just $4 million per gigalitre for agriculture (see Figure 2).

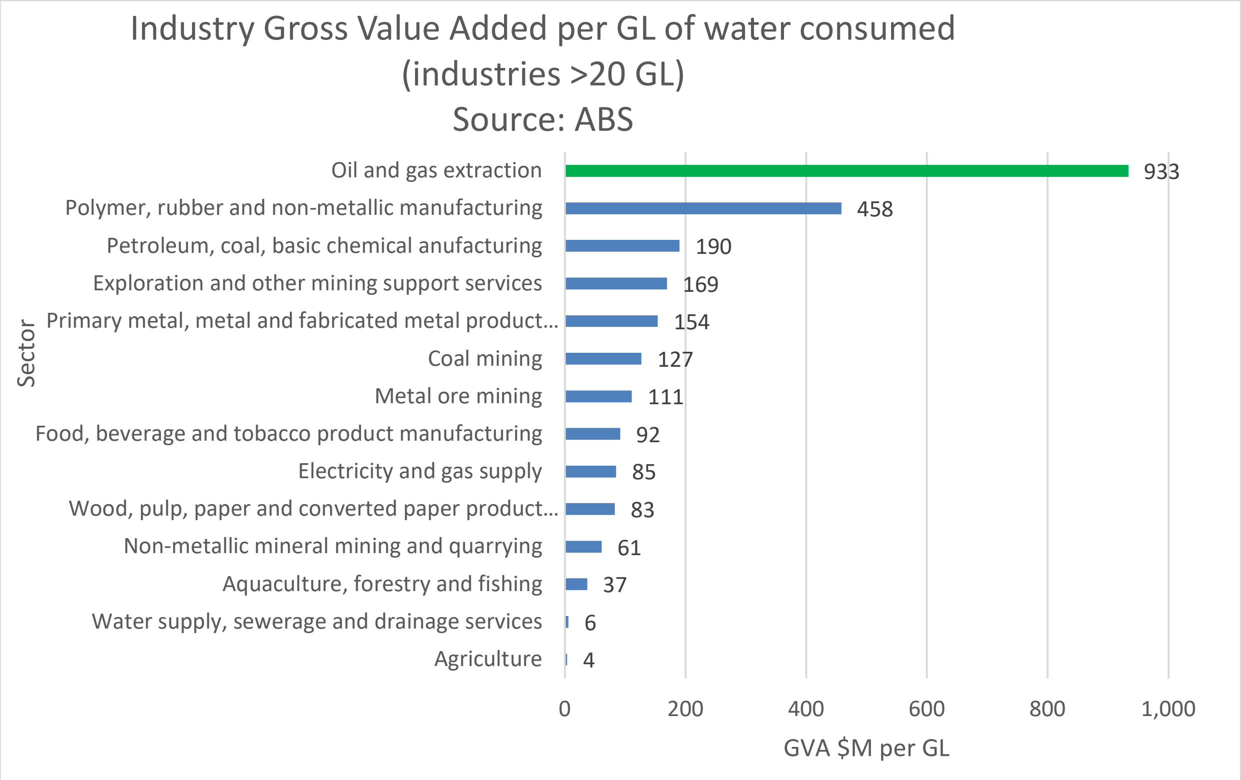

Figure 3 Industry Gross Value Added per GL of water consumed[15]

1.4. How water is used in the oil and gas industry

- Water is used in all stages of an oil and gas project from exploration to development. Water is used for well drilling, field development, infrastructure and construction, hydraulic fracturing, and other activities.
- The volume and type of water used is highly dependent on the geology and requirements of a field.
- The oil and gas industry is also a water provider to local users, treating the water associated with gas production and supplying it to farmers, local governments and other users.

The petroleum industry uses surface and groundwater sources. Operations such as drilling depend on access to groundwater.

Petroleum projects have three primary phases: exploration, development and production. Each stage has a different use of water depending on the type of petroleum development, project size, and location.

Petroleum operations also produce water which is brought to the surface along with hydrocarbons (see Produced Formation Water). In the case of coal seam gas, water is also a by-product of production, with a significant volume of water treated and then made available to farmers, local government and other users.

[15] Australian Bureau of Statistics (2007), *An Experimental Monetary Water Account for Australia*, Cat. No. 4610.0.55.005, August

A significant volume of water in Queensland is also treated to improve its quality from stock water to drinking water standards, then reinjected into Great Artesian Basin aquifers, increasing the water pressure in these aquifers and storing water for use by current and future generations.

Water can be used in petroleum operations to increase reservoir pressure and enhance the recovery of oil and gas. Table 1 below describes the relative water demand at each stage of the project lifecycle for different developments. The duration of each step varies across projects.

Table 1 Water and the Development cycle	Exploration	Development	Operations
Conventional	Low water demand	Low water demand	Typically low water use, potential to use water for enhanced recovery
Coal Seam Gas	Low water demand for drilling, hydraulic fracturing may or may not be required	More wells, camp supply, construction, dust suppression	Low water demand
Shale / Tight Gas	Few wells, low water demand, hydraulic fracturing may be required	Hydraulic fracturing (predominantly), construction, dust suppression, camp supply	Low water demand

1.4.1. Exploration

Exploration for oil and gas resources starts with geological and geophysical surveys to identify areas of interest. As water is only required for human consumption and vehicle use, impacts are negligible.

1.4.2. Oil and Gas Development

Where a commercial resource is located, a well is used to flow oil and gas to the wellbore. Any pressure in the reservoir above hydrostatic pressure will cause fluids or gas to flow up the wellbore. If the pressure is not sufficient the resource may be pumped or lifted.

Typically, oil and gas occurs under pressure within the reservoir and will flow into the wellbore and then to the surface. In conventional reservoirs the gas can easily flow through the reservoir-rock pore spaces towards the wellbore. Unconventional reservoirs may need additional stimulation treatment to increase this flow.

As the field matures, secondary recovery (also called enhanced recovery) may be employed. In some cases, fluids (e.g. water) may be pumped into the ground to increase pressure and properties to release additional hydrocarbons. This technique has been employed in Australia.

1.4.3. Water found in oil and gas reserves (Produced Formation Water)

Water present in the geological formations where oil and gas resources are found is called Produced Formation Water (PFW) or, in coal seams, Associated Water (see below). This water is brought to the surface along with oil or gas and varies in quality and quantity from field to field. Natural gas arriving at the surface will contain water vapour, which is the main source of produced water in conventional gas fields.

PFW is made up of a range of components and may include petroleum hydrocarbons, suspended solids, dissolved oxygen and salt.[16] The volume and properties of produced formation water vary from location to location and over the productive life of a reservoir (for example the oil-to-water ratio decreases over time).

The disposal of PFW is highly regulated and managed in Australia. Industry uses a range of techniques to minimise, reuse and recycle, and treat PFW:

- Minimising PFW: dual completion wells (downhole water sink), mechanical blocking devices, downhole separators, subsea separation, etc.
- Reuse and Recycle: underground injection, irrigation for crops, industrial use, dust control, etc.
- Treat: Treated then managed according to State regulations.

1.4.4. Water used in drilling

Water is consumed in well drilling. The amount of water used depends on how many times the mud is reused in different wells and the lifetime production of each well. In Australia, the general rule of thumb for onshore wells is approximately 1 ML per well for drilling. Drilling muds are expensive to produce, so they are constantly recirculated in the well and recycled for use in other wells.

1.4.5. Water used in Enhanced Recovery

Enhanced Recovery (or secondary production) generally refers to maintaining reservoir pressure to sustain economic rates. At this point, new wells can be drilled to inject water (or other fluids) into the reservoir. Enhanced recovery is generally deployed in conventional oil extraction activities.

The injection well is positioned some distance from the production well, with the position chosen based on an understanding of the reservoir characteristics. The injection water may be obtained from seawater, reuse of produced water, from purpose-drilled brackish water wells, from freshwater sources or from municipal wastewater sources. Seawater is typically used offshore, or at onshore sites near the coast.

Australia’s Barrow Island Windalia reservoir is Australia’s largest onshore Enhanced Recovery project and was developed in the late 1960s. It is estimated that using water to manage the field pressure

[16] Swan et al, Environmental implications of offshore oil and gas development in Australia, 1994

effectively reduced the field decline rate from approximately 18 % per annum to less than 2 %—adding millions of barrels in recovery and years to productive field life.[17]

1.4.6. Water used in Hydraulic fracturing

Hydraulic fracturing injects water-based fluids at high pressure into rock formations deep underground to create tiny fractures that enhance the flow of oil and gas. The process has developed over more than 65 years and has been applied to millions of wells around the world, including more than 1,500 wells in Australia since the 1960s. Hydraulic fracturing is also used in renewable (geothermal) energy production and to enhance the productivity of water bores.

The fluid is a water-based mixture containing sand or other solids, called proppants, that can prop open the newly created fractures. The amount of water used in hydraulic fracturing varies depending on resource and the amount of stages required. The source of water for hydraulic fracturing is an important consideration for industry, particularly in new and remote field locations.

Numerous Australian and international reviews have found that the risks associated with hydraulic fracturing can be managed effectively with a robust regulatory regime.

In Queensland, less than 10 per cent of all wells have been hydraulically fractured, without incident. Hydraulic fracturing in the Cooper Basin has occurred for many decades without incident. In Western Australia, hydraulic fracturing has been used extensively to assist with the recovery of oil and gas from conventional resources – an estimated 800 wells have been hydraulically fractured since 1958, without incident.[18]

1.4.7. Associated Water

Associated water refers to the water that naturally exists in petroleum formations. Coal seam gas is adsorbed to the coal matrix by the hydrostatic water pressure. The removal of water in the coal seam reduces the pressure, enabling the gas to be released from the coal. More information on Associated water from coal seams can be found in Appendix 1: Coal Seam Gas and Associated Water.

2. Existing safeguards in place to prevent the damage, contamination or draining of Australia's aquifers and water systems

- Conservation and protection of groundwater and surface water is a high priority during all oil and gas activities.
- All surface activities that could potentially affected water resources are regulated and controlled.
- Studies and decades of experience show the risk of groundwater and surface water contamination is very low.
- When a well reaches the end of its life, it is decommissioned (plugged and abandoned). This is done to a high standard to ensure long-term containment and isolation from geological formations.[19]

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[17] Hartanto Lina, Widjanarko Wisnu, Muna Diala (2011) The success story of Windalia waterflood optimisation through integrated asset management in a mature field. The APPEA Journal 51, 726-726. https://doi.org/10.1071/AJ10106

[18] Department of Mines and Petroleum (2017), Gas Fact Sheet: Hydraulic Fracture Simulation, Government of Western Australia, http://dmp.wa.gov.au/Petroleum/Hydraulic-fracture-stimulation-20018.aspx.

[19] Report into the shale gas well life cycle and well integrity, CSIRO. December 2017.

Conservation and protection of groundwater and surface water is a major priority during all oil and gas activities.

The use of chemicals during drilling, cementation and hydraulic fracture stimulation of wells is controlled, strictly regulated and managed to minimise environmental risk. Studies and decades of experience show the risk of groundwater and surface water contamination is very low.

The Australian petroleum industry focuses on conducting all aspects of its activities safely and sustainably. Conservation and protection of ground water is a priority. Environmental protection during oil and gas production is achieved by:

- Designing wells to standards that protect aquifers by ensuring multiple failsafe levels of protection;
- Isolating all fluids that might have a detrimental impact; and
- Being transparent and consulting with communities and government agencies before, during and after activities.

The oil and gas sector is committed to ensuring that its impacts on the environment are minimised. To ensure the adequate protection of groundwater it is common practice that operators use a number of risk mitigation measures, including robust well construction, safe handling and use of chemicals and extensive environmental monitoring.

Ensuring that well integrity is maintained throughout the life of operations is critical to safety and the protection of the environment. Wells are routinely inspected and subjected to maintenance. The industry is committed to monitoring and fixing any wells that are not functioning to the standards required.

All surface activities that could potentially affect water resources (such as drilling, construction, transport etc) are strictly regulated and controlled. The management of chemicals and materials on the surface are not unique to the oil and gas industry and comprehensive regulation and risk management is in place.

2.1. Water management

Water management is an essential component of oil and gas operations. Although the volume of water used by the oil and gas industry is considerably lower than in the agriculture, power and many other sectors, oil and gas operations do involve the handling and management of produced water, wastewater and rainfall run-off.

There are a number of industry practices adopted under Environmental or Safety Management Plans developed and implemented in accordance with legislative requirements which mitigate and reduce the risks of petroleum activities damaging water quality and quantity. These include:

- Detailed well design, testing and monitoring during all stages of well construction, hydraulic fracture stimulation, production testing, suspension, development and decommissioning.
- Monitoring local weather and climate information to make informed decisions regarding site operations.
- Ensuring site environmental inductions for all site personnel and contractors include protective measures to prevent avoidable discharge into, or contamination of, waterways, groundwater or established drainage systems.

- Ensuring appropriate storage of fuel and other flammable and combustible liquids in accordance with "*AS1940:2004 The storage and handling of flammable and combustible liquids*".
- Maintaining stormwater containment systems.
- Having a procedure in place to manage large quantities of water (e.g. pumping to an existing dam or watering point).
- Regular inspection and integrity checks of flowback tanks.
- All access roads, culverts and creek crossings maintained in proper working order.
- Ensuring adequate freeboard is maintained in ponds to allow for a prolonged period of intense rainfall.
- Ensuring all pipes and hoses are in good condition and fit for purpose to minimise risk of leaks from pipe.
- Periodic inspections of the site's stormwater and waste water containment systems.
- Refuel and transfer chemicals at a distance from drainage lines.
- Ensure site is equipped with spill clean-up equipment.
- Ensure well control critical equipment and systems on stimulation equipment are fit for purpose, certified, maintained in good working order and tested as required.
- Ensure appropriate well control training/certification for rig personnel.
- Ensuring sufficient distance between exploration targets and aquifers.
- Continuous real-time pressure, rate and volume monitoring during fracturing stimulation to ensure an immediate response in the unlikely event a loss of containment occurs.
- Maintaining all wastewater systems in working order to minimise impact on groundwater

2.1.1. Protection of Surface Water

The management of water, chemicals and other substances on the surface is a key consideration for the oil and gas industry.

Proper handling of fluids that are returned to the surface is crucial. Once hydraulic fracturing fluids return to the surface, they are typically stored in tanks or lined pits to isolate them from soils and shallow groundwater zones. Most studies into hydraulic fracturing have found that, overall, surface spills of fracturing fluids pose the greater risks to water than hydraulic fracturing.

The risks associated with water and chemicals handling are common to many industries such as agriculture and transport. Possible sources of impact on water quality may include:

- accident with chemical spills when handling the fracturing fluid and flowback fluid;
- leakage of fluid through pipelines during flowback; and
- erosion and leaching from cuttings, drill mud.

Oil and gas production involves use of fresh water, fracturing fluids, flowback water and produced water, chemicals and additives, as well as drilling muds and drill cuttings.

Best practice is to minimise the amount of these materials on site, contain materials as fully as possible, reuse or recycle to the greatest extent feasible, and dispose responsibly any residual materials offsite.

Operators develop detailed waste management plans that consider all of the planned handling, treatment and disposal of waste. Best management practices are applied to avoid contaminating water supplies, bodies of standing water (e.g. lakes, swamps, etc.) and watercourses.

A recent study by the Department of Environment and NICNAS identified stringent protective measures imposed by state and territory and Commonwealth governments for the petroleum industry and found that the probability of a surface spill damaging water resources is very low and that "*we can be confident that it can be used safely*".[20]

2.1.2. Protecting Groundwater

The risk of contamination of aquifers by drilling or fracture stimulation fluids is very low for numerous reasons, including:

- Few coal seam gas wells require fracturing – only six per cent of the wells drilled in Queensland have required hydraulic fracturing;
- Hydraulic fracturing fluids are 90 to 98 per cent water and sand. Additives make up a relatively small proportion of fluids; most additives are benign;
- The few additives which could, in theory, present a potential risk to human health or the environment would need to be discharged in large quantities, over a long period, to reach concentration levels which could affect the much larger volumes of water present in aquifers. Such a scenario would require an exceptional failure of preventative measures to occur and continue undetected over a protracted period;
- Natural barriers – i.e. thick layers of impermeable rock separating aquifers and wellheads – isolate the point of fracturing from aquifers;

There are unsubstantiated claims about the potential risk of fractures propagating into aquifers. Based on current technology and geological data (including thousands of metres of sealing rock between aquifers and the fracture stimulation targets), experts agree that there is very little risk that fracture propagation will lead to contamination of shallow aquifers. For example, research commissioned by the Australian Government found deeper[21].

A recent report by the CSIRO found that chemicals remaining underground after hydraulic fracturing are unlikely to reach people or groundwater dependent terrestrial ecosystems in concentrations that would cause concern. Risks are therefore likely to be very low. Risks from naturally-occurring chemicals in the coal seam mobilised by hydraulic fracturing are also likely to be very low for the same reasons.[22].

Generally, the risks of aquifer contamination can be assessed on three levels:

1: Concentration and toxicity

While a number of additives are used in hydraulic fracturing, very few of these additives could pose a risk to the environment or human health. The additives used in hydraulic fracturing are well known and regulated by State governments. The additives used are placed hundreds of meters beneath the surface, in very low concentrations (much lower than those used in swimming pools). Risks at the

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[20] Department of Environment, (2017) National Assessment of Chemicals (page 11) http://www.environment.gov.au/system/files/resources/03137f85-1bea-46a4-b9e7-67d985b4aeb5/files/national-assessment-chemicals-overview.pdf

[21] For example - Department of Environment, (2017) National Assessment of Chemicals (page 11) http://www.environment.gov.au/system/files/resources/03137f85-1bea-46a4-b9e7-67d985b4aeb5/files/national-assessment-chemicals-overview.pdf

[22] CSIRO (2017) Deeper groundwater hazard screening for chemicals used in coal seam gas extraction - Overview , http://www.environment.gov.au/system/files/resources/370d0bcd-8fe2-436f-88d7-1c3361ef8cd5/files/deeper-groundwater-hazard-screening-research-overview.pdf

surface relate to transportation, storage, and handling of chemicals which are common to all industries that use chemicals and are effectively managed by existing regulations.

2: Likelihood that the chemicals remain in the ground

Drilling fluids are mostly returned to surface for proper disposal or recycling for reuse in the next well. Cementation chemicals are contained in the cement. For fracture stimulation operations, 40 per cent to 60 per cent of the stimulation fluids return to surface as the well is flushed and cleaned out in the following weeks. This material is either disposed of through regulated facilities, or recycled. Over the life of a gas well – which may be decades – the pressure gradient towards the well ensures that any chemicals that may be freed up over time are swept to the well and up to the surface for proper processing.

3: Likelihood the chemicals will migrate to uncontrolled areas

The volume of stimulation fluid is carefully calculated and monitored to ensure it cannot travel material distances from the well. Typically, there are hundreds if not thousands of metres of rock between a fracture stimulation and any sensitive aquifers such as those used for domestic or agricultural purposes. This can be monitored with seismic or tracer technologies to verify the models for fluid travel.

2.1.3. Ensuring well integrity

Concerns around well integrity are often raised in relation to the potential for oil and gas wells to leak and cause water impacts.

An oil or gas well is a technically advanced bore hole that reaches hundreds to thousands of metres beneath the earth's surface to tap petroleum resources. In Australia, wells can vary in depth from 300 meters to 2,000 to 4,000 metres deep. For the industry, these are not challenging depths; overseas, wells beyond 10,000 metres are becoming common. Water wells for agriculture or domestic use are usually less than 100 metres deep.

Controlling the gases and liquids as they are brought to the surface relies upon long-term well integrity. Not only does the well have to contain the petroleum products inside the well, it must also ensure that subsurface rock layers and any related aquifers penetrated by the well remain isolated from each other. Achieving all this requires high standards of well design and construction.

Structural elements termed well barriers are essential in both the design and construction of wells. There are numerous types of barriers, including well casing, drilling muds, and blowout preventers. These barriers function as containment envelopes to prevent unintentional fluid flow between the geology and / or the atmosphere. The barriers have built-in redundancies to reduce the risks that gases or liquids can escape from a well anywhere along its length, enter a well from untargeted zones, or migrate from one geological zone to another.

Development of oil and gas resources using modern well cementing and completion techniques leads to excellent wellbore integrity. Technological advances are continually improving well integrity and leak detection.

2.1.3.1. *Well Casing ensures isolation of zones*

The well is lined with multiple layers of pipe (also called 'casing').

Image 1 Well Casing

Using several casing strings helps back up the integrity of the well if one of the pipes fails. Cement is pumped into the casing between the well and the rock, and between the various strings of casing. This isolates rock or aquifer zones, and prevents unwanted flow between rock zones or inside the well itself. This use of multiple casing strings and cement is the first line of defence for well integrity. There are usually three strings:

- Conductor casing – to secure the near surface section – soil and gravel etc -8 $^5/_8$" diameter
- Intermediate casing – from surface down to the base of weathered or weak strata – 6 $^5/_8$" diameter
- Production casing – down to the top of the target formation – 4 ½" diameter

All strings are cemented in place to isolate any aquifers.

2.1.3.2. *Well Cementing ensures well integrity*

Cement is a critical component of well construction and cementing is a fully designed and engineered process. Cement is used in casing at the time of well construction, as well as in plugging at the time of well abandonment, and less commonly to address production or perforation issues.

- It is important to note that the cement used in well construction is a highly engineered, specialised product. It is not the same as the cement used in traditional construction activities such as building and civil works. Well cementing practice and design has decades of research to underpin it. Special formulations and additives are available to customise cement to individual well conditions, including increased resistance to gas migration, naturally occurring chemical ions, low pH environments, carbon dioxide (CO_2), high temperatures, sulphate, and mineral acids (King, 2012). Designs may call for using different cements for casing than for plugging a well.

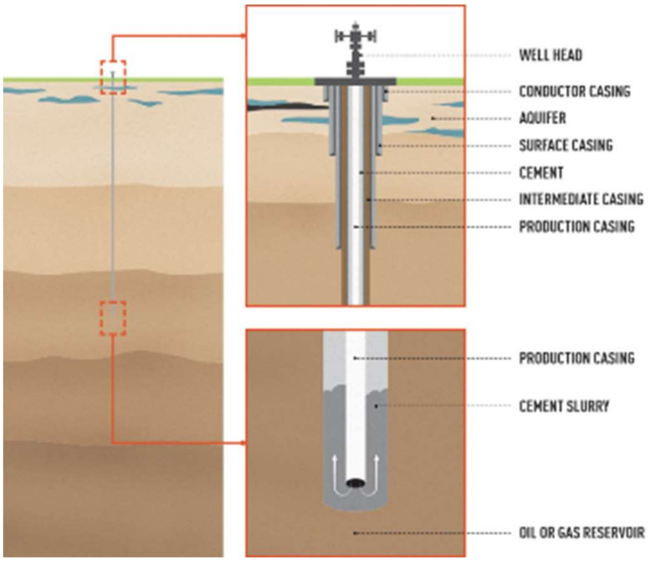


Image 2 Well Casing and Cementing Casings and Cementation:

Image 3 Multiple Pipe

2.1.3.3. Well failure is very rare

Historically, the highest instance of well barrier integrity failures appears to be related to insufficient or poor-quality cementing coverage to seal aquifers or non-reservoir hydrocarbon-bearing formations. In older wells, this was probably due to a lack of information on non-reservoir hydrocarbon-bearing geological layers and the regulatory regime under which the wells were constructed.

As described above there are multiple barriers in place to protect wells. The terms “well failure” and “well integrity” have sometimes been misunderstood.

A failure of a well barrier element will usually result in a well with *reduced* integrity. A reduction in well integrity does not necessarily mean any environmental impact. If a barrier has failed, there are actions that can be done to restore the failed well barrier (such as re-working the well). Failure of all barriers is called a ‘loss of well integrity’. The obvious consequences of a loss of well integrity is blowouts or leaks that can cause material damage, personnel injuries, loss of production and environmental damage.

A single barrier loss is more common than a complete barrier loss. Studies indicate that wells are extremely unlikely to have barrier or well integrity failures when wells are constructed according to modern construction standards.[23]

The United States has the world’s longest history of oil and gas production, and the most intensive drilling programs. The Ground Water Protection Council in the US examined more than 34,000 wells drilled and completed in the state of Ohio between 1983 and 2007, and more than 187,000 wells drilled and completed in Texas between 1993 and 2008. Included in the study period were more than 16,000 horizontal shale gas wells, with multi-staged hydraulic fracturing stimulations, completed in Texas.

[23] Stone et al. 2016b.

The data[24] shows only 12 incidents in Ohio related to failures of (or graduate erosions to) casing or cement – a failure rate of **0.03%.** In Texas, the failure rate was only about **0.01%.** Obviously zero is the aim, but this is still a very low percentage considering the large number of wells drilled. A recent review by King and King (2013) of the data from 253,090 wells in Texas found that only 4 in every 100,000 (0.004%) wells constructed to modern standards experienced a loss of well integrity, compared to 0.2% for older wells.

The Queensland Gasfields Commission has released some information on well integrity in that state.[25] The cementing 'failure' rate after testing, remediation, and follow-up according to the Queensland code has been zero. The likelihood and therefore risk of a subsurface breach of well integrity is assessed to be very low to near zero.

- In July 2015, the Petroleum and Gas Inspectorate advised that, from 2010 to March 2015, 6,734 CSG exploration, appraisal and production wells had been drilled in Queensland.
- According to the P&G Inspectorate, no leaks have been reported for subsurface equipment. This is consistent with recent scientific field measurements which found, in a sample of 43 wells "...no evidence of leakage of methane around the outside of well casings..." (Day et al, 2014: p2).
- There have been 21 statutory notifications (a rate of 0.3%) under the well construction code concerning suspect downhole cement quality during construction.
- For all of these 21 notifications, the gas companies followed up with subsequent testing to assess well integrity and undertake any remedial work.
- The P&G Inspectorate followed-up on all 21 notifications to ensure that the tests, and any required remediation work, conducted on the well was successful before gas production commenced, with the company also having appropriate monitoring programs in place to ensure ongoing integrity of the well.

In 2015, the Western Australia Department of Mines and Petroleum (DMP) conducted a survey of 1,035 non-decommissioned wells (both offshore and onshore wells) which found that: "*the vast majority of petroleum and geothermal wells are drilled, completed, produced and decommissioned without any adverse environmental impacts*".[26] DMP found that, of the 953 active petroleum wells surveyed, 9% have had production tubing failures and 3% have had production casing failures well away from aquifers which were still protected by the surface and conductor casings. There have been no failures of surface or conductor casings.

2.1.3.4. Long term well integrity can be achieved

Once a well has reached the end of its useful life, it must be decommissioned and remediated (the common industry term is 'plugged and abandoned'). Steps taken to remediate a well are usually well defined by the relevant regulator. A typical well remediation uses a drilling rig to remove any equipment in the wells, such as subsurface pumps and pipe tubing. The rig then pumps cement into the well and sets mechanical plugs as a back-up, to create long-term barriers to fluid flow and isolate

[24] Kell, S. (2011), State Oil and Gas Agency Groundwater Investigations and their Role in Advancing Regulatory Reforms: A Two-State Review: Ohio and Texas, Ground Water Protection Council , fracfocus.org/sites/default/files/publications/state_oil__gas_agency_groundwater_investigations_optimized.pdf
[25] QLD Gasfields Commission (2016), Well Integrity. www.gasfieldscommissionqld.org.au/resources/gasfields/onshore-gas-well-integrity-in-qld.pdf
[26] S Patel, S Webster & K Jonasson, *Review of well integrity in Western Australia*, Petroleum in Western Australia, April 2015, p 24

rock zones. Once this is done, the well-head is removed, and, in onshore wells, it is cut off below ground level so that past practices such as agriculture can resume over the well site.

A properly remediated well is very different to a producing well that needs regular measurement and monitoring. A remediated well is designed to be safe and pose no material threat to safety and the environment for future generations. The industry restores the natural integrity of the formation penetrated by the wellbore. This isolates permeable and hydrocarbon bearing formations are isolated to protect underground resources, prevent potential contamination of potable water sources and preclude surface leakage.

The claim that 'cement can't last forever' is often made by industry opponents to suggest that, over time, all plugged and abandoned gas wells will leak – causing contamination of groundwater.

Modelling and analysis into well corrosion show that a properly designed and implemented well can last indefinitely. Yamaguchi, Shimoda, Kato, Stenhouse, Zhou, Papafotiou, Yamashita, Miyashiro & Saito (2013) have investigated the long-term corrosion behaviour of cement in abandoned wells under CO_2 geological storage conditions by simulating the geochemical reactions between the cement seals over a simulated period of 1,000 years. While alteration of the cement seals was found after a period of time, the alteration length after 1,000 years was approximately one meter, leading to the conclusion that cement will isolate CO_2 and upper aquifers over the long-term.[27]

Cement plug integrity in CO2 subsurface storage was also assessed by Van der Kuip, Benefictus, Wildgust & Aiken (2011)[28]. Using estimates for degradation after 10,000 years they likewise came to similar conclusions stating that "*mechanical integrity of cement plugs and the quality of its placement probably is of more significance than chemical degradation of properly placed abandonment plugs*" (literature on corrosion and cement degradation considers CO2 stored at high pressure to be more aggressive than methane).

2.1.4. Potential for hydraulic fractures to act as pathways for aquifer contamination

Concerns have been raised about the potential for hydraulic fracturing activities to reach water-bearing formations, overlying aquifers or nearby water bores.

Recent studies by the CSIRO and others have looked into the possibility of shallow groundwater being impacted due to hydraulic fracturing migration from deeper aquifers. Based on modelling studies, the authors concluded that the likelihood of hydraulic fracturing reaching a water resource is low when the vertical separation between the reservoir and the overlying aquifer is large and other natural pathways (such as faults or leaky wells) are absent.

CSIRO research also found that chemicals remaining underground after hydraulic fracturing are unlikely to reach people or ecosystems in concentrations that would cause concern. This conclusion

[27] Kohei Yamaguchi, Satoko Shimoda, Hiroyasu Kato, Michael J. Stenhouse, Wei Zhou, Alexandros Papafotiou, Yuji Yamashita, Kazutoshi Miyashiro, Shigeru Saito, *The Long-term Corrosion Behavior of Abandoned Wells Under CO2 Geological Storage Conditions: (3) Assessment of Long-term (1,000-year) Performance of Abandoned Wells for Geological CO2 Storage*, Energy Procedia, Volume 37, 2013, Pages 5804-5815, ISSN 1876-6102, www.sciencedirect.com/science/article/pii/S1876610213007467.
[28] M.D.C. van der Kuip, T. Benedictus, N. Wildgust, T. Aiken, *High-level integrity assessment of abandoned wells*, Energy Procedia, Volume 4, 2011, Pages 5320-5326, www.sciencedirect.com/science/article/pii/S1876610211007922.

is based on natural dilution and degradation that reduce concentrations to negligible levels. Risks are therefore likely to be very low.[29]

Chemical management and water

The chemicals used in hydraulic fracturing are commonly occurring and used for a range of applications outside of oil and gas extraction.[30]

In December 2017, the Australian Department of Environment and Energy (DoEE) and the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) released an assessment of chemicals associated with coal seam gas extraction in Australia.

This study examined the risks to health and the environment from surface (above-ground) chemical spills. The NICNAS assessment focusses on what it describes as "worst-case" scenarios, which are highly-implausible and assume that all the safety and handling precautions required by law are not used.

The NICNAS assessment found the most significant potential risk to public health and the environment was exposure to chemicals after a large-scale transport spill, a risk facing any industry that uses chemicals. The chemicals used for hydraulic fracturing in the CSG industry accounts for less than one hundredth of one per cent of chemicals transported by road in Australia. Extensive regulation of heavy vehicle movements and chemical storage already minimizes the risks identified.

Studies from the CSIRO and NICNAS have confirmed that the use of chemicals in the coal seam gas (CSG) industry poses little risk to the community or the environment.

In five technical papers, the CSIRO found that residual chemicals remaining underground after hydraulic fracturing are unlikely to reach people or ecosystems in concentrations that would cause concern and therefore risks are very low. The CSIRO studies are the latest independent research to again confirm that, properly regulated, hydraulic fracturing is safe.

3. The Regulatory framework surrounding the oil and gas industry's water use

- The oil and gas industry is one of the most highly regulated industries in Australia.
- Under the Constitution the states and territory governments have primary responsibility for managing water resources
- State Governments that host activity have an established suite of legislation, regulation, and reporting requirements that apply to the oil and gas industry.
- The Commonwealth has a role in facilitating a collaborative approach to water management, such as through COAG.
- The Commonwealth regulates the oil and gas industry and water impacts under Federal Environmental Legislation. However, there is no value in expanding the 'water trigger' to include other projects.

Water issues have long been managed under comprehensive approvals regimes at the State level. This constituted responsibility has required States to develop detailed assessment processes for the

[29] CSIRO (2017) *Deeper groundwater hazard screening research* https://www.csiro.au/en/Research/Major-initiatives/Unconventional-gas/CSG-chemicals

[30] Department of Environment. What does fracking fluid contain? http://www.environment.gov.au/system/files/pages/2d9f9167-3826-4d59-8be5-67c8c731fb59/files/what-does-fracking-fluid-contain-factsheet.pdf

impacts of an activity on water resources and for water use. These processes require scientific, social and economic analysis of both surface and groundwater at both a local and regional scale to ensure potential impacts are understood, mitigated and managed.

The water used and produced by the Australian oil and gas industry is comprehensively managed and regulated. State and Territory governments are primarily responsible for the management of water resources within their jurisdictions (see State Government Regulation for further detail). The Federal Government has a role in water management in certain circumstances under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). This includes water resources as they apply to coal seam gas projects (the water trigger).

The oil and gas industry accesses water for operations in strict accordance with the framework relevant in that jurisdiction. A summary of the arrangements as they apply to water is below. Further detailed information on the regulation that applies to the oil and gas industry can be found at Attachment 2 – Government Regulation by State.

3.1. State Government regulation of water

State Governments, as constitutional owners of the resource, have the lead in the management of their water resources. Where cross-border issues exist, cooperative arrangements are in place.

State Governments are active managers of water resources given the importance of these resources to communities across their States. Ongoing and detailed regulatory reviews occur and these enable the detailed consideration of all issues including social, economic, and environmental outcomes.

For example, in 2017 the Queensland Government introduced a new water plan covering the Great Artesian Basin and Other Regional Aquifers (the GABORA Plan). Development of the plan included a comprehensive consultation process during which 57 submissions were received and 26 workshops were held across Queensland. The Queensland Government also regularly convenes a Water Engagement Forum which consists of a broad range of community, environment, and resource industry groups.

The Queensland Government has also introduced in recent years new requirements covering the take of and use of water by resource industries including:

- A Coal Seam Gas Water Management Policy
- Make good arrangements that apply to all resource projects
- Beneficial use requirements and standards
- Specific standards for the construction and operation of water storage dams associate with resource projects
- Water management conditions within environmental authorities
- Water reporting
- Bore assessment
- The development of regional underground water impact reports
- Amendments to water rights such that petroleum projects must apply for authorisation for the take of ‘non-associated’ water.

All social, economic, and environmental issues resulting from the take and use of water by extractive projects are therefore comprehensively considered and, where necessary, acted on as part of existing Queensland Government water reform process which are ongoing and will continue to be refined and reformed in the future. Similar processes and arrangements exist in other States and Territories (see Section 5).

The development and approval process for oil and gas projects is rigorous and provides an additional layer of regulation for project-specific water management. No other water user is subject to the same level of regulation. Scientific, social and economic analysis of both surface and groundwater at both a local and regional scale is undertaken to ensure potential impacts are understood, mitigated and managed.

It is important to note that the regulatory regimes in which we operate have evolved and adapted over time as information is collected. In this regard APPEA supports regulatory process that consider adaptive management systems that allow gaps in the framework to be addressed.

Adaptive management involves continually monitoring a process to evaluate its effectiveness, and improving the process based on this evaluation. It requires transparent planning systems and implementation strategies, and a strong emphasis on monitoring and reviewing to ensure emerging information is reflected in future planning.

Regulation does not come without cost. Too often there is perceived to be a trade-off between environmental outcomes and economic growth. This has led to a regulatory environment that limits sensible economic development without achieving any particular environmental outcomes, causing project delays and costs being driven up as well as otherwise viable projects being cancelled.

APPEA advocates for effective, efficient and streamlined regulation and assessment processes. In this regard APPEA seeks to identify ways to reduce the regulatory burden without also reducing environmental protection.

The Commonwealth Government and state and territory governments should, as a priority, continue to consider their regulatory regime to ensure it is efficient and conditions are necessary. Governments should also continue to continue to seek bilateral agreements under the EPBC Act which accredit state government approval processes that meet the required environmental standards. Bilateral agreements should be accompanied by an assurance framework that demonstrates the agreements are being adhered to, environmental outcomes are being achieved, and that the regulatory burden on project proponents is lower than is currently the case.

4. Conclusion

The continued development of petroleum resources in Australia is important for energy security, economic development and growth. There are significant climate benefits in transition to increased use of natural gas.

The Australian oil and gas industry takes its commitment to protect water resources seriously and employs the highest standards in operations and well design.

The risks associated with oil and gas extraction in Australia are managed under a comprehensive regulatory framework, that ensures all risks are considered and managed. The oil and gas industry is arguably the most highly regulated users of water in Australia, despite not being the biggest water user.

Appendix 1. Associated Water from Coal Seams

- Associated water is water that is pumped from the coal seams in order to extract gas.
- Water production by the Queensland natural gas industry accounts for a small fraction of national water use.
- In Queensland, associated water is regulated under numerous acts of legislation, including the Petroleum and Gas (Production and Safety) Act 2004; Petroleum Act 1923; Environmental Protection Act 1994; and the Water Act 2000
- The Underground Water Impact Report (UWIR) by the Office of Groundwater Impact Assessment indicates that water production by the CSG industry will have a localised impact on existing private water bores in Queensland.
- If a petroleum activity in QLD impacts on the capacity of a landholder's bore the relevant company is required to make good the impact.
- CSG water quality varies across regions, but typically has a quality which restricts its highest beneficial use to stock watering.
- Almost all associated water produced in Queensland is treated and made available for beneficial use with most being used in the agricultural industry.
- Landholders receiving treated water use the water to increase irrigated cropping and livestock watering - boosting agricultural production, economic flow-on opportunities and community benefits.
- The Darling Downs region in Queensland accounts for a significant proportion of the petroleum industry's onshore water take and because of the industry the region is now one of the most extensively studied and monitored aquifer systems in the world. All work to date indicates there will be minimal impacts on existing water users as a result of the industry's water take.

In Australia, coal seam gas resources are primarily located in Queensland and New South Wales.

All coals contain natural gas to some extent. In the early days of coal mining, removing gas from mines was a major challenge if mining was to proceed safely. In modern times, the gas in coal became seen as a valuable energy resource.

CSG Water

CSG is adsorbed into the coal matrix and is held in place by the pressure of formation water. To extract the gas, a well is drilled into the coal seam and formation water from the coal cleats and fractures is pumped and withdrawn. The removal of water in the coal seam reduces the pressure, enabling the CSG to be released (desorbed) from the coal micropores and cleats, and allowing the gas and 'produced water' to be carried to the surface.

No two wells or coal seams behave identically and associated water production can vary from a few thousand to hundreds of thousands of litres a day, depending on the underground water pressures and geology. A well will deliver most of its water at the start of the pumping phase. As the water is pumped from the coal formation, the pressure is released from the seam, and the gas begins to flow.

Associated water production and gas production are inversely proportional. As water rates decline, gas production increases. (Figure 4 Gas and water flor for a typical coal seam gas operation)

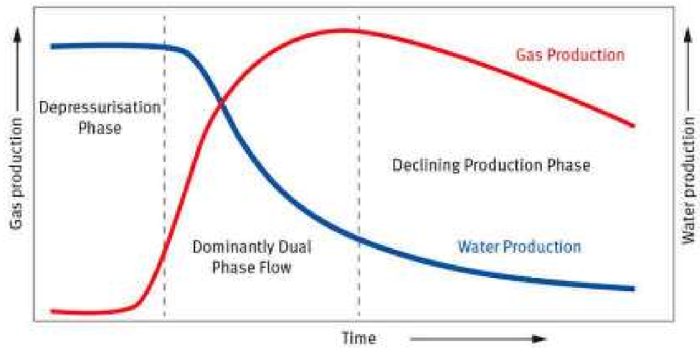


Figure 4 Gas and water flor for a typical coal seam gas operation

The water pumping phase is unique to producing gas from coal seams. But the drilling techniques, surface equipment and gas compositions are not materially different from conventional gas production, which has been going on for decades in Australia. Not all coals are suitable for production. Commercial viability depends on the permeability of the coal, and its ability to flow gas, as well as the costs of drilling and proximity to infrastructure and customers.

Coal is naturally fractured. Cracks in the structure of the coal are referred to as “cleats”. Water and natural gas are trapped in these cleats. Coals with more cleats are more permeable, which enhances the rate at which the water and gas can move through the coal’s structure.

Coals with lower permeability do not require as much water to be pumped to reduce the pressure on the coal. This is why some operations – for example in NSW and Queensland’s Bowen Basin – produce lower volumes of water. Areas with higher permeability generally produce higher volumes of water. Different CSG operations produce differing amounts of water.

Quality of Associated Water

Water trapped in situ contains salts and minerals that were part of the inland seas in which they were formed. Water that has entered the coal seam via aquifer recharge will collect salts and minerals as it travels through the surrounding geological formations. These salts and minerals are then captured in the water within coal seams in the same way that they are found in surrounding aquifers.[31]

Associated water quality varies across regions, but is typically high in total dissolved solids, bicarbonate, hardness, and silica. The water contains mainly sodium chloride varying from 200 to more than 10,000 milligrams per litre, sodium bicarbonate and traces of other compounds. Co-produced water is generally brackish, with salinity levels ranging from about 300 to 10 000 milligrams per litre (mg/L) By comparison, the salinity of water supplies for Australian towns can range from less than 250 up to about 1000 mg/L, and seawater is about 35 000 mg/L[32]

Consequently companies have invested in water treatment to improve the quality of the water for beneficial use in line with the Queensland Government’s water policy[33]. The most common

[31] CSIRO (2014) Great Artesian Basin and Coal Seam Gas. Factsheet 14-00589. Canberra
[32] Australian Government (2017), Independent Expert Scientific Committee. http://www.iesc.environment.gov.au/publications/csg-extraction-and-co-produced-water#fn4
[33] Coal Seam Gas Water Management Policy 2012 https://www.ehp.qld.gov.au/assets/documents/regulation/rs-po-csg-water-management-policy.pdf

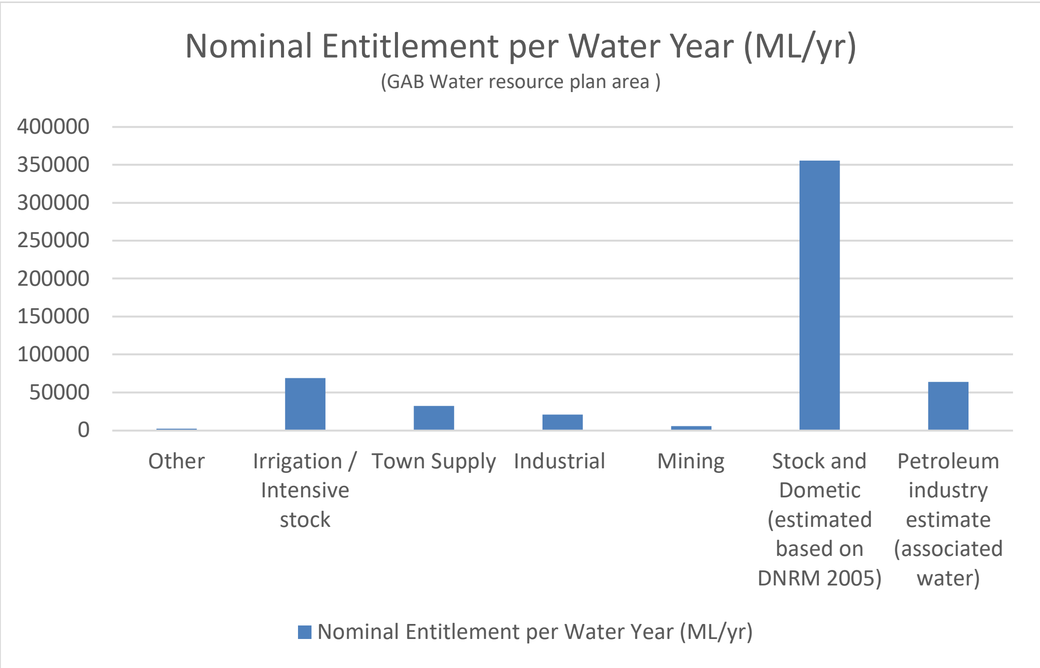
treatment system is reverse osmosis (RO) desalination with suitable pre-treatment steps have been employed to remove elevated salts and other compounds before CSG water can be used beneficially. One common form of beneficial reuse of the treated water is the irrigation of agricultural crops and forestry.

Associated water volumes

The volume of produced water extracted from each well can vary considerably between wells and regions depending on geological conditions. During the planning phase for gas field development, estimates of co-produced water volumes are necessary to formulate appropriate management arrangements. As the gas field is further developed, more representative data is available on well yield, enabling volumetric predictions to be refined over time.

The total volume of co-produced water in Queensland (Surat CMA) is estimated to be approximately 66 GL per year. The rate of associated CSG water extraction is less than initially expected due to the nature of the coal being encountered. The Great Artesian Basin (GAB) contains 65 million gigalitres (GL) of water.[34,35]

There are around 6,500 licences and 21 water permits in Queensland. Cumulatively, Queensland water users take about 315 GL per year from the Great Artesian Basin.



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[34] Great Artesian Basin Coordinating Committee (2014) *Great Artesian Basin Strategic Management Plan - Progress & Achievements to 2008* - *http://www.gabcc.org.au/images/DL_684_.pdf*

[35] CSIRO, 2008. *Background report on the Great Artesian Basin. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project.* Contributing author Herczeg, A.L. http://www.clw.csiro.au/publications/waterforahealthycountry/mdbsy/technical/S-GreatArtesianBasin.pdf

Non-Associated Water Use

Non-Associated Water is the water that is required for authorised petroleum activities but intentionally abstracted from a target aquifer with the express purpose of being used within the project.

The demand for water by the petroleum industry is often misunderstood and overestimated. Demand for non-associated water is short duration, with the highest demand being during construction activities prior to production. Long term demand is in small volumes. Overall water demand from the petroleum industry is expected to decrease as the primary construction phase of the large LNG developments in South-Eastern Queensland is completed.

Aquifers and CSG wells

When water is produced from a well, there is a decline in the water pressure in the deeper formations around the individual well. Under the Queensland regulatory framework, an area of concentrated development, where impacts on water pressure in aquifers are likely to be overlapping from multiple petroleum operations, can be declared a cumulative management area (CMA).

In 2012, the Queensland Government commissioned the preparation of the *Surat Underground Water Impact Report*[36] which covers the vast majority of producing coal seam gas operations in Queensland. This report was updated in 2019.

In the CMA, the Office of Groundwater Impact Assessment (OGIA) is responsible for:

- predicting the regional impacts on water pressures in aquifers
- developing water monitoring and spring management strategies
- assigning responsibility to individual petroleum tenure holders for implementing specific parts of these strategies

The report collated information on regional aquifers, existing water bores and petroleum wells, as well as the number and location of further wells to be drilled as part of the CSG industry's development. It used this information to forecast the expected level of impacts. The report also identified "immediately affected areas" and "long-term affected areas".

[36] https://www.dnrm.qld.gov.au/ogia/surat-underground-water-impact-report

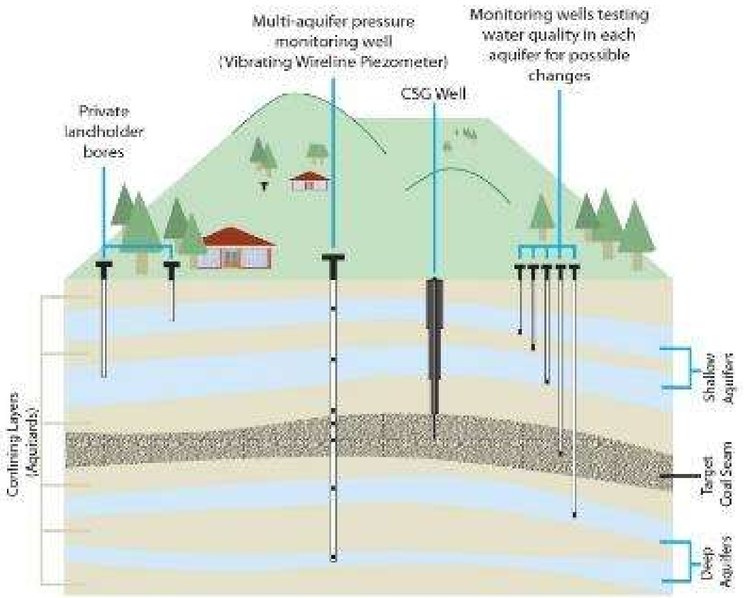

Image 4 CSG wells, landholder and groundwater monitoring bores (Source: Capital Energy Group)

The immediately affected area is defined as the area where water level impacts will exceed a nominated threshold level within a three-year period. Long-term affected areas are those that will be affected at any time in the future.

The threshold levels have been set at greater than five-metre decline in water level, in consolidated aquifers (i.e. sandstone aquifers) and three- metre decline in unconsolidated aquifers (i.e. sand aquifers).

This information was collated into one mega-model[5] to predict areas that may experience future groundwater impacts. The cumulative model covers an area the size of Germany and is referred to as the Surat Cumulative Management Area.

Gas companies have installed close to 1,500 monitoring points to detect any changes in aquifer pressure (using vibrating wireline piezometers) or changes in the chemistry in the aquifers underlying their permit areas. This information is delivered to the Queensland Office of Groundwater Impact Assessment (OGIA[37]) on a six-monthly basis.[5] Tenement holders are required to "Make-Good" on any bore level decline by providing alternative water supplies to the landholders. This may include drilling new, deeper bores, or supplying treated water to the affected properties.[4]

Beneficial use of associated water

Where properly managed and treated, CSG associated water can be reused in a range of different ways including irrigation. Regulatory requirements in Queensland ensure where possible associated water is used for a purpose that is beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependent industries.[38] Beneficial reuse can include:

[37] https://www.dnrm.qld.gov.au/ogia/role
[38] https://www.ehp.qld.gov.au/management/non-mining/csg-water.html

- Industrial Reuse–e.g. cooling water which would otherwise have been taken from local streams or groundwater
- Agricultural Reuse – reducing the need to extract water from local aquifers
- Injection – increasing the volume of water stored in local aquifers
- River Discharge – blending with seasonal non-permanent streams

In order to fulfil the requirements of the CSG Water Management Policy, companies are required to investigate options for beneficial reuse of the CSG water and to treat the water so that it is fit for purpose. While the level of salt in CSG water varies depending on the source, CSG water treatment processes typically involve desalination, and the most commonly used desalination technique is reverse osmosis.

Industry in Queensland has invested more than $3 billion in water treatment infrastructure, and almost all of the 66 GL produced by the industry is treated to meet strict water quality standards and beneficially reused[39]. The largest beneficial use is irrigation for farming, and about one-quarter of the water removed from local coal seams is returned to aquifers.

Two main processes are used to treat water drawn from coal seams:

Desalination

Capital cities around Australia have adopted desalination to produce drinking water from the ocean. The industry is using the same proven technology to purify water it withdraws from coal seams.

Amendment

Water with a low salt content can be treated by using an amendment process. This involves changing the mineral make-up of the water to produce water that is suitable for the intended purpose. The suitability of amended water for any other uses is determined by the water quality and is regulated by the state government.

After desalination a brine (salty water) is produced. Industry works within strict government guidelines to ensure brine is always managed safely and responsibly. At Roma, the brine left over after desalination is reinjected into deep underground aquifers which are already high in salt. In any new areas of operation in future, this will be dependent on the geology of the areas.

CASE STUDY: CSG water used to grow crops

The Fairymeadow Road Irrigation Pipeline (FRIP) project was delivered by Origin on behalf of Australia Pacific LNG. The project involved construction of the 1,870 megalitre irrigation storage dam located on the Monreagh property, the Monreagh pump station, the pipeline along Fairymeadow Road, and offtake points for participating landholders.[40]

The FRIP project provides the opportunity for landholders to supplement their cropping programs with new irrigation.

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[39] https://gasfieldscommissionqld.org.au/shared-landscapes
[40] Origin Energy – Fairymeadow Road. Water to Landholders (2017) https://www.originenergy.com.au/content/dam/origin/about/our-approach/docs/OurApproach-2016-Fairymeadow-Road.pdf

This irrigation scheme is an example of the CSG industry working with local farmers for mutual benefit. It allows the Fairymeadow area to be farmed more intensively, which leads to increased local jobs in agriculture, and a financial boost for the local agricultural contractors and associated agricultural businesses. This supply of water is especially important in times of drought.

Water began flowing to participating landholders in April 2014, filling on-farm dams and allowing farmers to prepare fields for planting winter crops which have since been harvested.

During 2016, the program delivered 11,208 ML of treated water to participating landholders. Treated water is delivered via pipeline from reverse osmosis water treatment facilities at Talinga and Condabri and stored in Monreagh Dam, and transferred to landholders via the Fairymeadow Road Irrigation Pipeline.

The FRIP project forms part of Australia Pacific LNG's broader CSG water management strategy, which uses a variety of solutions to find the best outcome for water resources according to local conditions.

The FRIP project is a practical application of the Queensland Government's Coal Seam Gas Water Management Policy (2012) which requires CSG companies to find beneficial uses for treated CSG water, and demonstrates how the agricultural and resources industries can work together to develop shared benefits.

About the Fairymeadow Road Irrigation Pipeline Project:

- Seven participating landholders
- Covering an estimated 3,500 hectares
- 15 gigalitres of treated water per year during peak production
- A 22 km water distribution pipeline along Fairymeadow Road
- A 1,870 megalitre irrigation dam, located on the Monreagh property (Monreagh Dam) which provides buffer storage
- A pump station at Monreagh Dam
- Irrigation off-takes for each participating landholder property along the water pipeline
- Water delivery gates to measure flow at each participating landholder property
- Talinga Water Treatment Facility
- Condabri Water Treatment Facility and booster pump station.

Image 5 Treated water being used for irrigation (Source: APPEA)

CASE STUDY: Chinchilla News.

The ebbs and flows of CSG water use.

The Chinchilla News. 27th May 2016[41]

IT WAS the first evening of a cutting horse event at the Chinchilla Showgrounds several months ago when two men sitting in the stands were talking farming. The man on the right leant in to the man on the left after a lengthy conversation and said: "But I'll tell you what, those blokes who are on Coal Seam Gas (CSG) water, I'd like to know how they're doing." "Yep," the man continued. "That CSG water must be like having a licence to print money."

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Greg Bender, who farms a 2000 acre patch of earth called Burradoo, just south of the Chinchilla Weir, laughs and shakes his head when it's put to him like that. "I wouldn't say it's a licence to print money," he said, chuckling. "It's a licence to turn it over. It's definitely been financially rewarding for us since it's come on stream, but it's been a lot of work and a lot of risk too."

41 Chinchilla News (2016) *The ebbs and flow of CSG water use* https://www.chinchillanews.com.au/news/the-ebbs-and-flows-of-csg-water-use/3034389/

Greg Bender on his property 'Burradoo' in Hopeland. **Matthew Newton**

To say the availability of treated CSG water through Queensland Gas Company's (QGC) beneficial re-use scheme has transformed Mr Bender's farming practices would be an understatement.

Originally a dry-land cropping set-up where he might have planted one crop every 18 months, Mr Bender now has 1800 acres of irrigation at his disposal.

"It's been three pretty solid years of building ditches, levelling paddocks and installing pipelines and pumps," Mr Bender said. "It was alright for the first 12 months because you didn't have the country - but then after the initial 12 months all of a sudden you've got another 1000 acres of irrigation and you're growing all these crops, so you've created all this extra workload just to grow the crops and then you're still trying to do the development work as well."

Mr Bender put in for and signed a contract with QGC for up to 4800ML/year across two properties, though it is unlikely he will ever actually receive those volumes of water. Teething problems at QGC's Kenya Water Treatment Plant meant the water allocations were inconsistent at first.

"It was just up and down; one month you'd get 100% and then all of a sudden the allocation might get halved for the month at a day's notice," Mr Bender said. Since then the allocations have become more consistent, though it is unlikely the scheme will ever reach its full potential.

Mr Bender estimates he has pumped about 6000ML in 32 months, or about 2400ML/year.

With the madness of the early years behind him, Mr Bender is now seeing the fruits of his labour.

Where once Burradoo's main crop was cotton, with single paddocks harvested once every two-three years, now he's got a continual cash flow. "Nearly every month we're selling something because we're growing crops all year round," he said.

The almost guaranteed supply of water has given Mr Bender the confidence to hedge his bets and take advantage of good commodity prices long before it's time to harvest. "There's a lot of marketing opportunities... we forward sold a crop of cotton six months ago because we knew we had the water to grow it and the price was good," he said. "Where's when you haven't got the water it's always in the back of your mind that I'm not game to forward sell it just in case.

"The classic at the moment is these chickpeas - you've heard them all talking about how chickpeas are going to be an all-time high this year? Well we haven't grown chickpeas in probably 10 years and we're probably going to grow half the farm under them now, because we can."

There are other benefits too - Mr Bender has had to put on three full-time employees to keep up with the increase in work and with all the pumping going on, machines need maintaining more often.Another positive he didn't factor into his plans is that with so much country under irrigation, any time there's a rainfall event - even a small one - the run-off goes straight into his dam.

"It's been a huge benefit to us," he said.

"We were probably a bit lucky because we were already existing irrigators and we had a lot of machinery and had built a channel down to the river based on the fact that we might be able to pump water with a flood harvesting licence."

Mr Bender said he looked at the figures and took a gamble, which it now seems will pay off."If it was as good as what they said it was, it would have been absolutely brilliant, but I mean, some water is better than none. That's all I looked at. I probably was a bit fortunate that I went holus bolus and worked out that'd be the maximum amount of water I could use per year and put in for it."

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Treated CSG water is piped from the Kenya Water Treatment Plant along a 20km pipeline into the Chinchilla Weir. To date Sunwater have delivered a total of 45,186ML since operations began in 2012/13.

So far this year, the pipeline has carried an average of 52ML per day. The pipes are capable of supplying up to 100ML per day. Some of that water is taken direct from the pipeline, as in the case of farms like Nine Mile Lucerne, on the Chinchilla-Tara Road.

The remainder enters into the weir. The CSG water accumulates in the weir over the course of the month, before it is let out in flows for other users downstream of the weir to take their allocations. While downstream releases of irrigation water cease when the weir water level drops below a certain point, treated CSG water must be released, regardless.

The Chinchilla Weir last week was sitting at 31% capacity. Treated CSG water is released from the weir regardless of water storage levels.

A Sunwater spokesperson explained this was because the purpose of releases from the Beneficial Use Scheme is to provide regular scheduled water supply for agricultural production including irrigation and stock water.

Farmers on the CSG water scheme run the risk of being fined $160 per megalitre if they do not use all of their allocation each month.

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Downstream of the weir on the banks of the Condamine sits 'Lallalindi', Don and Lorraine Bell's 840 hectare cattle property.

While other farmers on the scheme already had irrigation infrastructure in place, the Bells had to start from scratch.

In 2012, Mr Bell bought and installed a pivot in preparation for the supply of CSG water.

"The pivot's been in for about four years, but we went two years before we started getting water. The pivot just sat there. It was a most expensive bird roost," he said.

"That was one of the big issues from my point of view. We had to have our system ready to go when they started reverse osmosis on the water, and it was supposed to happen in 2011 or 2012, and it didn't.

"So everybody had to have their systems all ready. So here it was sitting there ready to roll and we didn't get any water for two years because (QGC) took longer to build their RO plant than what they thought it would."

These days, Mr Bell, like the rest of the farmers on the scheme, is receiving about half the allocation he thought he would. That's okay in the winter when he doesn't use as much water, but the hotter summer months are a squeeze.

The pivot waters about 35 hectares, half of which is under improved pasture with Rhodes Grass and the other half under forage sorghum and burgundy bean.

"It gives us a lot more flexibility in what we do because we've got that feed that can be produced nearly all the time - the problems are that sometimes in summer time we don't get enough water for what we want to do," he said.

"It would be better if we had more water... at the moment I'm only watering half of my area because our water is down, and then if they cut us back even more it's going to make it more difficult."

Because the Bells are only receiving half their total allocation, lack of water storage facilities becomes an issue - something which would be useful in the winter time.

But water storage costs money.

"We didn't want to go back into too much debt at our age," Mrs Bell said.

"None of our boys are probably going to come back onto the farm so we didn't want to set ourselves up with a big debt. It was a bit of a trial, really, to go ahead and do what we've done."

Mr Bell said that because they weren't irrigators before signing onto the scheme, they didn't have a storage, nor did they think they could afford to install one.

"150ML storage will cost $150-200,000 probably and we already had used enough money to set (the pivot) up down there," he said.

"We're actually looking into it at the moment. We've got some people giving us some technical advice on how we can go about building a storage and making our system a little more efficient."

Despite the ongoing issues with supply, Mr Bell said the pivot had given him more flexibility. In the past, there have been plenty of times where the Bells have had to sell their cows due to drought. He now runs 250 head of cattle, but in the past has had to cut his herd back during the dry.

During a period of severe drought in 2006, he had 32 cattle on the property.

"It was so dry the truck got bogged in the sand," he recalled.

Mr Bell hopes that with the CSG water allocation, that won't happen again.

"It doesn't drought-proof you, but you can deal with the dry times a bit easier," he said.

For more information on treated CSG water and the beneficial reuse scheme, click here.