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A REGULATORY REVIEW OF SHALE GAS AND TIGHT GAS IN WESTERN AUSTRALIA, SOUTH AUSTRALIA AND COLORADO

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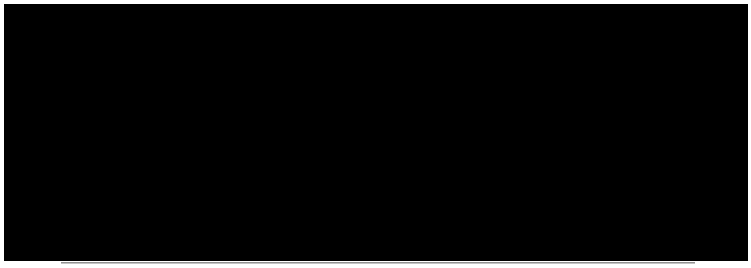
DECLARATION

The thesis is my own composition, all sources have been acknowledged and my contribution is clearly identified in the thesis. The thesis does not contain any work that I have published, nor work under review for publication.



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ABSTRACT

This thesis considers the regulatory frameworks that exist in Western Australia, South Australia and Colorado for developing shale and tight gas and the reforms that can be made to Australian regulation to overcome popular opposition to the industry. It examines the statutory provisions and best management practices concerning land access, water use, drilling, hydraulic fracturing, decommissioning and rehabilitation under the Petroleum and Geothermal Energy Resources Act 1967 (WA), Petroleum and Geothermal Energy Act 2000 (SA) and Oil and Gas Conservation Act (Colorado).

Colorado already has a highly developed shale and tight gas industry and may provide regulatory lessons for Western Australia and South Australia. Australia reportedly holds 437 trillion cubic feet of technically recoverable shale natural gas, which is the sixth largest reserve in the world. For some years, it has been assumed that the industry would develop these resources, but there is strong opposition. It is likely that Western Australia will continue to try to exploit shale and tight gas from reserves in the Canning Basin in the north of the State, but a newly elected State Government has recently implemented an executive ban on fracking in the South West, Peel and Perth metropolitan areas. South Australia continues to exploit shale and tight gas reserves in the Cooper Basin, which is the most prospective and commercially sustainable region for shale gas exploitation in Australia. Notwithstanding some popular concerns about the industry, particularly in the south-east of the State, South Australia's Energy Minister has publicly stated that the government does not support a ban, moratorium, social licences or any other effective veto on the exploitation of unconventional gas.

Parliamentary inquiries in Western Australia and South Australia have identified a number of key regulatory issues: land access arrangements, public disclosure of chemicals used in hydraulic fracturing, encouraging the use of recycling wastewater, baseline monitoring of aquifers and the publication of data, long-term well integrity and threats of groundwater contamination, surface spills and waste and chemical transport, and decommissioning and rehabilitation. Industry supporters argue that proper management makes it unlikely that industry operations pose significant risks. However, industry opponents have convinced some in government that, at least in more densely populated areas with high value land uses, the risks are too great. This thesis identifies the best regulatory approaches for addressing these issues, drawing particularly on the examples of Colorado's regulation of the shale and tight gas industries.

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ACKNOWLEDGEMENTS

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DEDICATION

To my wife, Kristy and children Alexander, Jonathan and Isabella who I love and adore.

LIST OF FIGURES

LEGISLATION

Aboriginal Heritage Act 1972 (WA)

Aboriginal Heritage Act 1988 (SA)

Aboriginal Affairs Planning Authority Act 1972 (WA)

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Colorado Oil and Gas Conservation Commission rules (2 CCR 404-1, et seq)

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Getty Oil Company v. Jones, 470 S.W.2d (618 (Tex.1971)

Gerrity Oil and Gas Corp. v. Magness 923 P.2d 261 (1995)

LIST OF ABBREVIATIONS

AA	Administrative Arrangements
ACOLA	Australian Council of Learned Academies
AM	Adaptive Management
CBCP	Case by case permitting
CDP	Comprehensive drilling plan
CSG	Coal Seam Gas
COGCC	Colorado Oil and Gas Conservation Commission
CDPHE	Colorado Department of Public Health and Environment
C&C	Command and Control
DMIRS	Department of Mines and Petroleum
DoW	Department of Water
DR	Drilling reservation
DPC	Department of State Development
DEWNR	Department of Environment, Water and Natural Resources
EUR	Expected Ultimate Recovery
EP	Exploration Permit
EL	Exploration Licence
EIR	Environmental Impact Report
EPA	Environment Protection Authority
EIA	Energy Information Administration
FMP	Field Management Plan
GAB	Great Artesian Basin
GRACE	Gravity Recovery and Climate Experiment
GWMA	*Ground Water Management Act 1963* (Colorado)
HD	Horizontal Drilling
IEA	International Energy Agency
MOU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration of the U.S.A
NRMA	*Natural Resources Management Act* 2004 (SA)
NRC	Natural Resources Committee of South Australia
OBA	Objective Based Approach

OGCA	*Oil and Gas Conservation Act (Colo. Rev. Stat. § 34-60-100, et seq.)*
PGERA	*Petroleum and Geothermal Energy Resources Act* 1967 (WA)
PGEA	*Petroleum and Geothermal Energy Act* 2000 (SA)
PP	Precautionary Principle
REM	Roseneath Epsilon Murteree
RBA	Risk Based Approach
RiWI Act	*Rights in Water and Irrigation Act* 1914 (WA)
SCEPA	Standing Committee on Environment and Public Affairs Western Australia
SEO	Statement of Environmental Objectives
SF	Self-Regulation
SLTO	Social licence to operate
Tcf	Trillion cubic feet
U.S.	United States of America
UG	Unconventional Gas
WD	Well Design
WI	Well Integrity
WIH	Well Integrity Hazard
WMP	Well Management Plan

1 INTRODUCTION AND THESIS

> In order to realise the enormous potential of shale gas, great skill, persistence, capital and careful management of any impacts on ecosystems and related natural resources will be required. There must also be an informed community and transparent and effective regulations and companion codes of practice. Provided we have all these in place (and the right rocks), shale gas could be an important new energy option for Australia.[1]

1.1 Introduction

The popular opposition to the exploitation of unconventional gas (coal seam gas, shale gas, tight gas) worldwide raises valid social and environmental questions about the sustainability and regulatory capacity of Australian states and territories to manage any future development. The author questions whether regulatory frameworks can be designed to address these questions to an extent that satisfies the Australian community. There will be significant new risks and challenges if Australian jurisdictions choose to exploit shale and tight gas.[2] The thesis will determine whether there are gaps in the regulatory regimes of Western Australia and South Australia in terms of land access, water access and quality protection, regulation of well technology for drilling (and hydraulic fracturing) and decommissioning and associated issues that can be addressed by learning from Colorado and the way it regulates shale and tight gas exploitation.

The thesis is primarily concerned with shale and tight gas in Western Australia, South Australia and Colorado, though it will briefly discuss coal seam gas given it is an unconventional gas, alongside shale and tight gas. One commentator argues, quite rightly, that the exploitation of shale and tight gas in Australia has not been as controversial as other forms of mining, 'yet'.[3]

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[1] P Cook, V Beck, D Brereton, R Clark, B Fisher, S Kentish, J Toomey and J Williams, Engineering Energy: Unconventional Gas Production, Report for the Australian Council of Learned Academies, May 2013, p 35 at https://acola.org.au/wp/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf

[2] Rahm, B, G and Riha, S, J, 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci: Processes Impacts* 1400, 1409 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H

[3] P Cook, V Beck, D Brereton, R Clark, B Fisher, S Kentish, J Toomey and J Williams, Engineering Energy: Unconventional Gas Production, Report for the Australian Council of Learned Academies, May 2013, p 19 at

There is little doubt that the shale and tight gas reserves in Western Australia and South Australia have the potential to deliver Australia 'energy security, a cleaner energy mix and economic growth.'[4]

Australia has enough natural gas, both offshore and onshore, to sustain domestic and export markets beyond 2030.[5] There are considerable onshore coal seam gas reserves in Queensland and New South Wales, large prospective shale gas reserves in the Northern Territory, Western Australia and South Australia and tight gas deposits in Western Australia and South Australia.[6] Western Australia's Canning Basin and South Australia's Cooper Basin are Australia's most prospective basins for shale and tight gas development based on 'the large number of wells and seismic data; hydrocarbon discoveries; size; locality to infrastructure and market; relative ease of locating wells and lower cost to complete and tie wells into existing pipelines.'[7] Whilst the Canning basin and Cooper basin alone are likely to be the catalyst for Australia's next resources boom, the arid conditions, particularly in the Canning basin and its remoteness will lead to significant risks and challenges in terms of exploration, production and abandonment.[8]

The existence of a large gas deposit is meaningless, especially if communities and legislators choose not to publicly support the regulatory regimes that are necessary for exploitation. Some insist, quite rightly, that significant resource estimates can create unrealistic commercial viability expectations.[9] Western Australia's Department of Mines, Industry Regulation and Safety (DMIRS) estimate that shale and tight gas exploitation in Western Australia is five to

<https://acola.org.au/wp/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf

[4] Natural Gas from Shale and Tight Rocks An overview of Western Australia's Regulatory Framework Department of Mines, Industry Resources and Safety, February 2014, pg 5 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-102D.pdf

[5] Daniel T.B. Leather , Alireza Bahadori , Chikezie Nwaoha , David A.Wood, 'A review of Australia's natural gas resources and their exploitation' (2013) 10 *Journal of Natural Gas Science and Engineering* 68-88

[6] Ibid.

[7] Kane Rawsthorn, Shale Gas Prospectivity Potential, AWT International, Prepared for: Australian Council of Learned Academies, 23 January 2013 at https://acola.org.au/wp/PDF/SAF06Consultants/AWTShale%20Gas%20Prospectivity%20Potential%20Jan2013.pdf

[8] Ibid.

[9] Dr Nina Triche, Unconventional Resources: Applying the World To (Western Australia), Water Management for Shale and Tight Gas Resources, June 8-9, 2015 – Perth, Western Australia

ten years away due to a lack of skilled personnel, a lack of drilling rigs capable of deep horizontal drilling and an absence of infrastructure.[10]

It is likely that Australia's desire to exploit shale and tight gas will be hampered by, amongst other things, 'long lead times, high capital and operational costs, necessary price environments to attract investment, and the importance of overcoming regulatory and environmental constraints.'[11] Regulatory bodies will likely face considerable hostility if they permit operators to exploit shale and tight gas in areas where there are competing natural resources and environmental values. Australia's shale and tight gas regulatory regimes are 'ever-changing, complex, and not harmonized.'[12] Some believe the Unites States 'was caught off guard by the shale gas revolution and [they] have been playing catch-up since.'[13] For this, and other reasons, it is vitally important for Western Australia and South Australia to learn from the United States to ensure that regulatory frameworks are in place to address the social and environmental issues associated with shale and tight gas exploitation.

1.2 Social licence to operate

Shale gas resources often go undeveloped in the United States, 'not for the lack of a legal license, but rather for the lack of a social license'.[14] A social licence forces governments and operators to protect community interests and environmental values from negative impacts while taking advantage of any exploitation opportunities that may arise.[15] Operators use a social licence to manage socio political risk by complying with the rules imposed by regulators

[10] Natural Gas from Shale and Tight Rocks An overview of Western Australia's regulatory framework (Department of Mines, Industry Resources and Safety, February 2014) pg 5 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-102D.pdf

[11] Energy Source, Why U.S. Shale Gas will not be a Cookie Cutter Model [Online] (2012) http://theenergysource.blogspot.com/2012/06/why-us-shale-will-not-be-cookie.html

[12] Ozwater, Water Quality Regulations for Unconventional Gas (accessed 23 January 2017) at www.ozwater.org/sites/all/files/ozwater/136%20SNeitzel.pdf

[13] Tim Boersma and Corey Johnson, Risks and Potentials of Shale Gas Revolution, Consequences for Markets and the Environment, (SWP Comments 39, German Institute for International and Security Studies, December 2012) pg 4.

[14] Don C. Smith and Jessica M. Richards, Social Licence to Operate: Hydraulic Fracturing-Related Challenges Facing the Oil & Gas Industry, University of Denver, Sturm College of Law, Working Paper No. 15-12, 2015, pg 2 at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2591988

[15] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, Doctor of Juridical Science thesis, The University of Western Australia, 2014, pg 65.

and the community.[16] The licence is a continuing social contract that sanctions a project from start to finish.[17] A social licence stems from a society's view that operators have ongoing public acceptance and approval.[18]

A social licence to operate can be theorised as a goal or set of rules that should be pursued.[19] It is 'not as simplistic as a company's stamp of a community's approval but rather it reflects an ongoing and negotiated process where a community objection of one element of a project does not necessarily mean that the full support is being threatened or withdrawn.'[20] A social licence is vital for operators, given that the failure to obtain one can result in ongoing conflict and dispute with local communities.[21] A social licence to operate is, in many ways, a risk management tool. If an operator can gauge its social licence, it can assess the level of risk linked to a project and take measures to reduce it.[22] This thesis has chosen not examine social licence to operate in specific detail, save to say that it is important for the reader to have a basic understanding of the concept which underlies the need for regulatory change in Australia.

1.3 Coal seam gas

The Standing Council on Energy and Resources published a national regulatory framework for natural gas from coal seams in 2013.[23] The Standing Council stated that a number of the approaches promoted in the coal seam gas framework may be appropriate for shale and tight

[16] Claire Richert, Abbie Rogers, & Michael Burton, 'Measuring the Extent of a Social License to Operate: The Influence of Marine Biodiversity Offsets in the Oil and Gas Sector in Western Australia' (2015) 42 *Resources Policy* 121, 121

[17] Damien Giurco, et. al., 'Responsible Mineral and Energy Futures: Views at the Nexus' (2014) 84 *Journal of Cleaner Production* 327

[18] Robert G. Boutilier & Ian Thomson, 'Modelling and Measuring the Social Licence to Operate: Fruits of a Dialogue Between Theory and Practice' (2011) *International Mine Management* ; Richard Parsons, Justine Lacey, & Kieren Moffat, 'Maintaining Legitimacy of a Contested Practice: How the Minerals Industry Understands its "Social License to Operate"' (2014) 41 *Resources Policy* 83, 84

[19] Jason Prno & D. Scott Slocombe, 'Exploring the origins of "social license to operate" in the mining sector: Perspectives from governance and sustainability theories' (2012) 37 *Resources Policy* 346, 347; Claire Richert, Abbie Rogers, & Michael Burton, 'Measuring the Extent of a Social License to Operate: The Influence of Marine Biodiversity Offsets in the Oil and Gas Sector in Western Australia' (2015) 42 *Resources Policy* 121, 121

[20] Justine Lacey, Richard Parsons, & Kieren Moffat, Exploring the concept of a Social License to Operate in the Australian Minerals Industry, CSIRO 7 (2012), (accessed 1 January 2018) < https://publications.csiro.au/rpr/download?pid=csiro:EP125553&dsid=DS3>

[21] Evan J. House, 'Fractured Fairytales: The Failed Social License for Unconventional Oil and Gas Development' (2013) 13 *WYO. L. Rev*. 5, 51

[22] Above, note 17.

[23] The National Harmonised Regulatory Framework for Natural Gas from Coal Seams 2013, Standing Council on Energy and Resources at http://www.scer.gov.au

gas.[24] The framework deals with, amongst other issues, well integrity, water management, hydraulic fracturing and chemical use.[25] These are all issues that require management in the context of shale and tight gas exploitation. Norton Rose Fulbright argue that, whilst there is no prospect of the coal seam gas framework being extended to shale gas, it is reasonable to expect that a corresponding harmonisation process may be implemented for shale and tight gas, with some of the recommendations in the coal seam gas framework informing the process.[26] The framework certainly has the capacity to influence the broader unconventional gas sector.[27]

The Standing Council on Energy and Resources insists that shale and tight gas jurisdictions can benefit from the framework, particularly in terms of produced water management, aquifer and ecosystem contamination, site remediation and well failure.[28] While some of the approaches in the coal seam gas framework may be suitable for shale and tight gas exploitation there has been no consideration of its transferability to date. Furthermore, there has been no assessment of how far we may be able to read across from coal seam gas issues to shale and tight gas. This thesis focuses on the shale and tight gas industry and does not attempt a detailed analysis of how much of the coal seam gas framework may apply to the shale and tight gas industry.

1.4 Risk and challenges - social and environmental

There are significant risks and challenges, both social and environmental, linked to shale and tight gas exploitation and the topic often prompts its opponents to use words like unsafe, risky, harmful, stressful, offensive and worrying.[29] Many in the community, particularly landowners are extremely concerned about the potential for groundwater contamination, fluid spillage, heavy vehicle traffic, and noise and property damage.[30] There is also increased scrutiny from

[24] Ibid.
[25] Ibid.
[26] Norton Rose Fulbright, Shale gas handbook, A quick-reference guide for companies involved in the exploitation of unconventional gas resources, June 2015 at http://www.nortonrosefulbright.com/files/norton-rose-fulbright-shale-gas-handbook-108992.pdf
[27] Ibid.
[28] Above, note 24.
[29] Hydraulic Fracturing: Unsafe, Unregulated, Public Citizen, Protecting Health, Safety and Democracy, (accessed 6 June 2018), < https://www.citizen.org/our-work/climate-and-energy/hydraulic-fracturing-unsafe-unregulated>
[30] ERCB Report 2011-A: Unconventional Gas Regulatory Framework - Jurisdictional Review, pp 5-7 at https://www.aer.ca/documents/reports/r2011-A.pdf

the media and the public and more regulatory attention is being given to the potential for aquifer contamination.[31]

The risks and challenges primarily, but not exclusively, relate to well spacing; hydraulic fracturing; water management; landowner/public concerns; environmental issues; regulatory processes; and information collection and dissemination.[32] There are significant concerns about the amounts of water required to carry out hydraulic fracturing, most of which is surface or groundwater.[33] There can be land use issues with transporting water (by truck and/or pipelines), on-site contamination and waste water disposal.[34] The exploitation of shale and tight gas has drawn considerable attention to the cumulative effect of infrastructure and water and large multi well pads, particularly in the United States, constantly operating.[35]

There are concerns with assessment and approval processes, debate about whether older regulatory regimes contemplate the cumulative impacts of shale and tight gas exploitation, whether there are adequate systems in place to manage water issues and the potential impact of hydraulic fracturing operations on nearby wellbores and shale and tight gas operations.[36] Some industry commentators are concerned with data collection and question whether data from conventional reservoirs has any relevance to shale and tight gas exploitation.[37] Data collection is highly contentious given it is costly and some argue that operators are inclined to suppress certain information.[38]

In the United States, communities are gravely concerned about 'degradation of or stress on water resources; road damage and increased truck traffic; threats to health; and changes in quality of life, including the influx of large numbers of new residents and workers associated with boomtowns.'[39] One of the most vocal groups in Colorado is based in Erie, a suburb north

[31] Id at 5
[32] Ibid
[33] Ibid
[34] Ibid.
[35] Ibid.
[36] Ibid.
[37] Id at 7
[38] Ibid
[39] Austin Shaffer, Skylar Zilliox & Jessica Smith 'Memoranda of understanding and the social licence to operate in Colorado's unconventional energy industry: a study of citizen complaints' (2017) 35:1 *Journal of Energy & Natural Resources Law*, 69, 73

of Denver. The group, commonly known as 'Erie Rising', is made up of local mothers who are considered anti-development.[40] Erie Rising is mainly concerned about a 'fear of pollution and health hazards for their children attending an elementary school located 1,500 feet from a proposed drilling site'.[41] The total number of complaints in Erie (between 2010-14) was fifty nine and related to, amongst other things, water quality, land and property damage, land reclamation, well pad grading and aesthetics.[42]

Western Australia's Standing Committee on Environment and Public Affairs received a submission as part of its 'Inquiry into the Implication for Western Australia of Hydraulic Fracturing for Unconventional Gas' stating that 'we can live without gas; we cannot live without clean water...A big NO to fracking from me, for my grand children's wellbeing and the future of our planet'.[43] Another argued that the 'devastation and degradation caused to large areas of America should be a very strong warning to Australia before we even contemplate such a dangerous mining practice here'.[44] Moreover, 'anyone giving support to these (often overseas-owned) mining companies will be responsible for any ill effects on the health of Australia'.[45] They continued that 'we are kept in the dark about these matters, but I think the Australian public has learned from events in the U.S and will not tolerate such dangerous and scientifically-unproved practices to go ahead on our soil'.[46]

South Australia's Natural Resources Committee 'Inquiry into Unconventional Gas (Fracking) in the South East of South Australia' received a submission stating that 'fracking has no place on this planet, it leads to polluted water aquifers and water catchments…it pollutes our drinking water and makes the locals sick! Oil, Coal and Gas are dying resources that should be left in the ground'.[47] Another submission argued that 'fracking has a wide range of risks & disadvantages, including contamination of ground water & surrounding landscapes &

[40] Id at 70.
[41] Ibid.
[42] Id at 79.
[43] Mary Sturmer, Submission, Inquiry into the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas, 18 August 2013
[44] Eileen Whitehead, Submission, Inquiry in the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas, 11 September 2013
[45] Ibid.
[46] Ibid.
[47] Justin, email sent to Patrick Dupont, Inquiry into Unconventional Gas and Fracking in SE of SA, 19 January 2015

farmlands & air quality…it would appear that such risks will not be effectively controlled & regulated by existing legislation or the bodies & departments to do such a task'.[48]

The Natural Resources Committee received submissions from citizens who felt that there was a 'high likelihood of ground water contamination, adverse impacts on landscape, adverse effects on agriculture, direct adverse environmental damage from drilling and fracking operations'.[49] One particular submission concluded that 'it is a silly (damn fool) thing to do for short term gain for the fossil fuel industry which should be *rapidly* phased out and replaced by renewable energy, including vehicles which run on renewable resources'.[50] Another submission stated that there is 'potential for water contamination caused by spills, leaks, chemicals and accidents, potential for well integrity failure due to finite lifespan of cement and steel, potential for industrialisation of landscape, unconventional gas fracking is as yet unproven technology…'.[51]

The International Energy Policy Institute argues that some jurisdictions regulate the shale gas industry 'with more success and openness than others.'[52] The Policy Institute insist that, for Australia to reach its shale and tight gas potential, its regulatory regimes should be reviewed and changed to provide a greater degree of 'clarity, transparency and community engagement.'[53] According to the Australian Council of Learned Academies (ACOLA) the development of best practice mechanisms assist in minimising the risks association with exploitation.[54] These practices have been described as 'state-of-the-art mitigation measures applied to oil and natural gas drilling and production to help ensure that energy development

[48] Joy Mayberry, email to Patrick Dupont, Inquiry into Unconventional Gas and Fracking in SE of SA, 12 January 2015
[49] Burwell Dodd, email to Patrick Dupont, Inquiry into Unconventional Gas and Fracking in SE of SA, 18 January 2015
[50] Ibid.
[51] Darryl Brooksby, Rivoli Bay Sailing Club, submission, Inquiry into Unconventional Gas and Fracking in SE of SA, 12 January 2015
[52] UCL International Energy Policy Institute Adelaide, Australia, Shale Gas in Australia: The Policy Options, Green Paper, October 2013, pg 4 at https://www.ucl.ac.uk/australia/files/shale-gas-in-australia-green-paper-final
[53] Ibid.
[54] P Cook, V Beck, D Brereton, R Clark, B Fisher, S Kentish, J Toomey and J Williams, Engineering Energy: Unconventional Gas Production, Report for the Australian Council of Learned Academies, May 2013, p 20,21 at <https://acola.org.au/wp/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf>

is conducted in an environmentally responsible manner'.[55] In Colorado, they are '…designed to prevent or reduce impacts caused by oil and gas operations to air, water, soil, or biological resources, and to minimize adverse impacts to public health, safety and welfare, including the environment and wildlife resources'.[56] The question of whether best management practices exist in Western Australia and South Australia, and to what extent, remains unanswered.

Some industry commentators argue, that regulating shale and tight gas exploitation is difficult, since operators do not always have the capacity to absorb new regulatory requirements; establishing where pollution emanates from can be difficult with wells, storage tanks and wastewater impoundments geographically dispersed and numerous; there are dispersed regulatory regimes; regulatory opposition increases transactional and political costs to regulatory proposals and there are significant data gaps.[57] ACOLA argue that there are no major technology gaps to cause development of shale and tight gas to be deferred, but they insist that there are significant knowledge gaps in relation to the environment that require further research.[58] While the industry may also argue that there is no justification for halting exploitation, it is crucial that they genuinely commit to a continued discussion of the associated risks and challenges, and contribute to developing policies that might address them. One independent reviewer of the industry has said that the risks and challenges associated with shale and tight gas exploitation can be controlled if robust regulatory regimes exist.[59]

The Northern Territory government recently concluded a Scientific Inquiry into Hydraulic Fracturing that resolved that 'no industry is completely without risk, and the development of any onshore shale gas industry in the Northern Territory is no exception'.[60] The Northern Territory Inquiry concluded that 'the challenges and risks associated with any onshore shale

[55] Best Management Practices, Intermountain Oil and Gas BMP Project, (accessed 6 June 2018) https://www.oilandgasbmps.org
[56] COGCC Rules and Regulations, Definitions (100 Series)
[57] Katherine E. Konschnik and Mark K. Boling, 'Shale Gas Development: A Smart Regulation Framework' (2014) *Environmental Science & Technology* A
[58] Cook, P, Beck, V, Brereton, D, Clark, R, Fisher, B, Kentish, S, Toomey, J and Williams, J (2013). Securing Australia's Future – Engineering energy: unconventional gas production,pg 29 at http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-6
[59] Allan Hawke AC, Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory, 2014, Executive Summary, page x.
[60] Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, April 2018, pg 59 (accessed 5 June 2018) https://fracking.inquiry.nt.gov.au/inquiry-reports?a=494327

gas industry in the Northern Territory can be appropriately managed'[61] by focusing on, for example, releasing appropriate land, decommissioning, monitoring and consulting with traditional owners.[62] As far as the Northern Territory government is concerned 'nothing is guaranteed... and with any new industry, it is not uncommon for problems to emerge'.[63] In response to the risks and challenges associated with shale and tight gas exploitation many governments have introduced bans and moratoria.

1.5 Bans and moratoria

Many would agree that an alternative to banning a harmful activity is regulating it.[64] The debate about whether hydraulic fracturing is safe has opened up a 'ban' versus 'regulate' divide within the anti-fracking community.[65] The conjecture about whether exploiting shale and tight gas is safe or unsafe has not stopped the anti-fracking movement's overall push to ban it.[66] In fact, many countries have banned hydraulic fracturing for various social, scientific and political reasons including France, Bulgaria, Romania, Northern Ireland, Spain and Switzerland.[67]

The exploitation of shale gas in Colorado led to environmental concerns and a desire for greater local control over development.[68] A number of local governments prohibited hydraulic fracturing.[69] However, these were deemed to be 'invalid and unenforceable' by the Colorado Supreme Court in 2016.[70] In Colorado a number of Memorandum of Understanding (MOUs)

[61] Id at 60
[62] Ibid
[63] Ibid
[64] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 206
[65] Global Shale Gas and the Anti-Fracking Movement, Developing Union Perspective and Approaches, Working Paper 1, Trade Unions for Energy Democracy, [June 2014], pg 11 https://unionsforenergydemocracy.ord
[66] Rebbeca Burns, 'A Fracktious Debate: Greens and divided on whether to regulate fracking or hold out for a ban' *In these Times*, 10 July 2013
[67] Petrol global news, 9 countries or regions that ban fracking, (assessed 1 January 2016) at https://petroglobalnews.com/2013/10/9-countries-or-regions-that-ban-fracking/amp
[68] Austin Shaffer, Skylar Zilliox & Jessica Smith, 'Memoranda of understanding and the social licence to operate in Colorado's unconventional energy industry: a study of citizen complaints' (2017) 35:1 *Journal of*
[69] Michael Wines, 'Colorado Court Strikes Down Local Bans on Fracking' *The New York Times*, 2 May 2016 ,https://mobile.nytimes.com/2016/05/03/us/colorado-court-strikes-down-local-bans-on-fracking.html
[70] Joel Minor, 'Local Government Fracking Regulations: A Colorado Case Study' (2014) 33 *Stanford Environmental Law Journal (SELJ)* 61; Bruce Finley, 'Colorado Supreme Court Rules State Law Trumps Local Bans on Fracking' *Denver Post*, 2 May 2016 at www.denverpost.com/2-16/05/02/colorado-supreme-court-rules-law-trumps-local-bans-on-fracking

were signed between local governments and operators that enabled development to proceed while addressing the concerns of local communities.[71]

In Western Australia, a submission to the Standing Committee on Environment and Public Affairs argued that 'given that fracking has only been in operation for 30 years in the United States and less than ten years in the eastern Australian states, so far the subsequent social costs seem to outweigh the benefits of the gas sourced'.[72] The submission insisted that 'due to a contentious history on the east coast of Australia and in north America and with Western Australia not requiring the gas reserves in the medium term, it is prudent to call a moratorium on the industry until all the issues are resolved'.[73]

Western Australia's Country Women's Association passed a motion at their 89th State conference 'requesting a moratorium on gas fracking in Western Australia until it could be proven by an independent body to be safe for the State's underground and surface water supply.'[74] The Country Women's Association was concerned that a large amount of water was required to hydraulically fracture wells and maintained that '…there is little enforceable regulation in WA to minimise the negative environmental impact of hydraulic fracturing of shale gas.'[75]

The Parliament of Western Australia passed the *Natural Gas (Canning Basin Joint Venture) Agreement Act 2013* (WA) 'to ratify and authorise the implementation of an agreement…to promote the natural gas exploration and development of the area of certain petroleum exploration permits in the Canning Basin region of Western Australia' ('the State Agreement').[76] The State Agreement allowed for the 'evaluation, development and

[71] Austin Shaffer, Skylar Zilliox & Jessica Smith 'Memoranda of understanding and the social licence to operate in Colorado's unconventional energy industry: a study of citizen complaints' (2017) 35:1 *Journal of Energy & Natural Resources Law* 69, 69 at https://doi.org/10.1080/02646811.2016.1216696

[72] David Rickson, Chairman Gingin Water Group, Submission, Inquiry into the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas,19 September 2013, (assessed 10 December 2013)

[73] Ibid.

[74] Anne Gething, CWA of WA, Submission, Inquiry into the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas, 15 August 2013

[75] Ibid.

[76] Mr Colin Barnett, Second Reading Speech, *Natural Gas (Canning Basin Joint Venture) Agreement Act 2013* (WA), Extract from Hansard, Assembly, Wednesday, 8 May 2013

exploitation of natural gas resources in the Canning Basin'.[77] In 2015, the Western Australia government extended the key dates after being advised by Buru Energy ('Buru') that the evaluation of the natural gas resources in the Canning Basin was progressing at a slower pace than was originally anticipated.[78]

In 2017, the newly elected Western Australian government terminated the State Agreement pending the outcome of a Scientific Review into Hydraulic Fracturing.[79] The government also announced that there would be a ban and moratorium on hydraulic fracturing, which covered existing and future petroleum titles in the South-West, Peel and Perth metropolitan regions, and a moratorium that prohibited the use of hydraulic fracturing throughout the rest of the state.[80] The future of fracking in Western Australia would be decided following a scientific review.[81]

The New South Wales government imposed a moratorium on hydraulic fracturing in December 2010 (which has since been lifted); the Tasmanian government has a moratorium until 2020.[82] In contrast, the South Australian government has publicly stated that it does not support a ban, moratorium, social licence or any other veto on exploration or extraction that would undermine the public rights (to ownership of petroleum rights).[83] The Victorian Parliament banned hydraulic fracturing and imposed a moratorium on any petroleum exploration and petroleum production in onshore Victoria until mid-2020.[84]

[77] *Natural Gas (Canning Basin Joint Venture) Agreement Act 2013* (WA) at http://www.slp.wa.gov.au/pco/prod/FileStore.nsf/Documents/MRDocument:24917P/$FILE/Natural%20Gas%20(Canning%20Basin%20Joint%20Venture)%20Agreement%20Act%202013%20-%20[00-a0-04].pdf?OpenElement

[78] Second Reading speech, *Natural Gas (Canning Basin Joint Venture) Agreement Amendment Bill 2015* (WA)at http://www.parliament.wa.gov.au/Parliament/Bills.nsf/3AD963612A77877C48257EB9000F7E60/$File/Bill144-1BSR.pdf

[79] Premier Mark McGowan, Canning Basin agreement to be terminated, Wednesday, 29 November 2017.

[80] McGowan Government implements fracking commitment,Thursday, 5 September 2017 at < https://www.mediastatements.wa.gov.au/Pages/McGowan/2017/11/Canning-Basin-agreement-to-be-terminated.aspx>

[81] Ibid.

[82] Tasmanian Government Policy Statement on Hydraulic Fracturing (Fracking) 2015 (accessed 1 May 2018), http://dpipwe.tas.gov.au/Documents/Tasmanian%20Fracking%20Policy%20Statement_26-2-15.pdf

[83] Belinda Willis, Energy Minister deals blow to anti-fracking campaign in SA's South-East, *The Advertiser*, 24 May 2017.

[84] *Resources Amendment Legislation (Fracking Ban) Act 2017* (Victoria)

A Private Members bill, the *Landholders' Right to Refuse (Gas and Coal) Bill 2015*, was introduced into the Commonwealth Parliament to give landholders the right to refuse access to their land without written authorisation and prohibit hydraulic fracturing for coal seam gas and shale and tight gas.[85] In late 2015, a Senate Committee recommended that the senate not pass the bill.[86] Throughout Australia it is apparent that there is greatest hostility to the shale and tight gas industry in areas of higher environmental values and sensitivity. It is likely that, in these areas, the shale and tight gas industry will never be permitted to operate. However, it is also likely that in other areas the community will accept governmental and industry arguments that the industry's operations can be adequately regulated to protect social and environmental values while exploiting the economic opportunities of shale and tight gas resources.

1.6 Methodology – Regulatory theory and Comparative law

A prominent academic with a keen interest in regulation insists that social problems and limitations prompt regulation.[87] Some believe regulation is an abstract concept used in various different settings.[88] In order to understand regulation one must 'acknowledge that imperfections and limitations impair decision making… and that regulation is here to stay.'[89] Despite the fact that jurisdictions use different regulatory tools, 'all are valid forms of regulation, and none is necessarily less stringent or effective than the others'.[90] The 'promotion of economic efficiency, environmental sustainability, morality, and the general welfare of the public…guarantee the imperfect nature of regulation'.[91]

[85] Senate Hansard, Senator Waters, Landholders' Right to Refuse (Gas and Coal) Bill 2015 (Commonwealth) at http://parlinfo.aph.gov.au/parlInfo/download/chamber/hansards/1da66012-4613-4c01-8369-b2c1421daaaf/toc_pdf/Senate_2015_03_04_3215_Official.pdf;fileType=application%2Fpdf

[86] Environment and Communications Legislation Committee inquiry into the *Landholders' Right to Refuse (Gas and Coal) Bill 2015*, pg 52.

[87] Barak Orbach, *What is Regulation? Regulation: Why and how the state regulates* (Foundation Press, 2012) 10 http://ssrn.com/abstract=2143385 ,

[88] Department of Treasury and Finance, 'Victorian Guide to Regulation (Guide, Government of Victoria, Australia, August 2011) http://www.dtf.voc.gov.au/CA25713E0002EF43/WebObj/VictorianGuidetoRegulationJuly2011/$File/VicotianGuidetoRegulationJuly2011.pdf

[89] Ibid.

[90] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, and Hannah Wiseman, 'The State of State Shale Gas Regulation', June 2013, pg 5 at http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-StateofStateRegs_Report.pdf

[91] Robert Baldwin, Martin Cave & Martin Lodge, *Understanding Regulation, Theory, Strategy, and Practice* (Oxford, 2nd Edition, 2012) 4

Regulation usually involves government intrusion in freedom and choices.[92] Some industry commentators insist that regulation is fundamentally about controlling and managing risks.[93] Those that support regulation view it as a tool governments use to exercise control over important economic and social activities; cynics consider regulation a burden on economic activity.[94] Those who support it reject arguments of regulatory trade-offs.[95] There is little doubt that what constitutes 'good regulation' is a matter of opinion.[96]

Some scholars of regulation suggest that '…to regulate means to control or direct others by rules or standards.'[97] For many, 'government regulation has connotations of a powerful authority making people do things they would not otherwise do and generally interfering in people's lives in intrusive and wasteful ways'.[98] Theories of regulatory development are at their 'most comfortable when considering the effects of a single regime on a sector or issue'.[99] Governments generally avoid establishing precise, central blueprints and, instead, draft lists of qualities they consider appropriate in a good regulatory regime.[100] They also typically spread enforcement and policymaking powers across numbers of agencies.[101] Some suggest that 'while regulation can assist with achieving the community's objectives, it can also impose unnecessary compliance burdens on the regulated'.[102] All regulation, regardless of approach, leads to unintended consequences, positive and negative.[103]

There are a number of specific regulatory approaches that are suitable for managing the exploitation of shale and tight gas and a single regulatory approach is incapable of accounting for all these, especially given that every approach is flawed in some way.[104] One industry commentator argues that there is no perfect regulatory model and regulatory success requires

[92] Ibid
[93] J Black, 'The Role of Risk in Regulatory Processes', in R. Baldwin, M. Cave and M. Lodge (eds), *The Oxford Handbook of Regulation* (Oxford, 2010)
[94] Robert Baldwin, Martin Cave & Martin Lodge, *Understanding Regulation, Theory, Strategy, and Practice* (Oxford, 2nd Edition, 2012) 4
[95] Frank Ackerman & Lisa Heinzerling, *Priceless: On Knowing the Price or Everything and the Value of Nothing* (The New York Press, 2004
[96] Above, note 87 at 37.
[97] Valerie Braithwaite, *Closing the gap between regulation and the community, Regulatory Theory, Foundations and applications* (ANU Press, 2017), 25
[98] Ibid.
[99] Robert Baldwin, Martin Cave & Martin Lodge, *Understanding Regulation, Theory, Strategy, and Practice*(Oxford, 2nd Edition, 2012) 63
[100] Id at 38.
[101] Robert Baldwin and J. Black, 'Decentring Regulation: The Role of Regulation and Self –Regulation in a "Post-Regulatory World"' (2001) *Current Legal Problems* 103-46
[102] Simon Robb, 'A best practice regulatory proposal for shale gas production', 2014, 83, 85
[103] Id at 84.
[104] Ibid.

a 'low cost, low risk regulatory system'.[105] In recent times, the value of distinct approaches to regulations has been studied, particularly in the context of environmental disasters.[106]

As well as commissioning its own external review,[107] DMIRS often examines international and interstate reviews and reports.[108] DMIRS argue that these provide a basis upon which it contemplates enhancements to Western Australia's regulatory framework and inform the industry about best practice methods.[109] It has become common practice for legislators and academics who seek to improve their legal system to look overseas, though it is certainly true that introducing laws from other countries can fail due to contextual differences.[110] As a result, in some cases a more systematic contextual approach may be required.[111] The author has chosen to use a comparative law methodology to review the shale and tight gas regulatory regimes of Western Australia, South Australia and Colorado. Comparative law is used to find 'general principles of law that have international legitimacy'.[112]

One comparative law theorist argues that 'comparing only legislation is risky when there is no information available on how it works in practice, and such a limited comparison is only acceptable for countries which are not the core of one's comparative research.'[113] To achieve its methodological aim the thesis will compare Western Australia, South Australia and Colorado's legislation and regulations and refer to a number of journal articles, academic papers, regulatory documents, government reports, industry documents, parliamentary committee reports and government reviews.

[105] Alan Hardacre, 'Better Regulation – What is at Stake?' (Training Paper, European Institute of Public Administration , 2008) 3 at http://www.eipa.eu/files/repository/eipascope/20080905132115_SCOPE2008-2_1_AlanHardacre.pdf

[106] Christel Koop and Martin Lodge, 'What is Regulation? An interdisciplinary concept analysis' (2017) *Regulation & Governance* 95, 95

[107] Tina Hunter, Regulation of Shale, Coal Seam Gas and Tight Gas Activities in Western Australia, Final, An analysis of the capacity of the Petroleum and Geothermal Energy Act 1967 (WA) to regulate onshore gas activities in Western Australia, July 2011

[108] Submission of the Legislative Council Standing Committee on Environment and Public Affairs: "Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas", Department of Mines and Petroleum, October 2013, Pg 5

[109] Ibid.

[110] Mark Van (Hoeke, 2015), 'Methodology of Comparative Legal Research'(2015), 1-35 *Law and Method* 3

[111] Ibid.

[112] Mauro Cappelletti, 'Comparative Law Teaching and Scholarship: Method and Objectives' (1994) *Asia Pacific Law Review* 7

[113] Mark Van (Hoeke, 2015), 'Methodology of Comparative Legal Research'(2015), 1-35 *Law and Method* 3

The same comparative law theorist insists that, sometimes, the act of 'comparing' is regarded as a standalone 'method' known as 'the comparative method' without additional explanation or specific guidelines.[114] The only other 'method' that goes beyond this is the 'functional method'.[115] The functional method does not just compare rules; it provides solutions to practical problems with opposing interests.[116] The functional method is based on the idea that 'there are relatively universal human attitudes to certain situations, such as taking care of children, respecting property rights, executing contractual obligations, compensating in one way or another damages caused by one's wrongful conduct, and so on.'[117]

Another comparative law theorist insists that the first task in the journey is to search for a social issue, or desire, experienced by the citizens subject to the legal structures under comparative analysis.[118] The differences in the way they are legally managed does not thwart the comparative study of such resolutions.[119] The same theorist argues that, to have a significant comparative study, 'we need to have a societal problem shared by the various systems included in the comparative study.'[120] The thesis is underpinned by the notion that to have an important shale and tight gas comparative study, 'the common point of departure must be a situation in which all the countries involved in the study have environmental problems of a common nature.'[121] As has been so articulately put before, 'it would make no sense to include countries in which such problems do not exist, because they are still in a pre-industrial stage of their economic development.'[122]

Some jurisdictions regulate the unconventional gas industry 'with more success and openness than others.'[123] The question of whether Colorado regulates shale and tight gas with more success than Western Australia and South Australia remains unanswered in the current

[114] Id at 8.
[115] Ibid.
[116] Ibid.
[117] Id at 11.
[118] Mauro Cappelletti, 'Comparative Law Teaching and Scholarship: Methods and Objectives' (1994) *Asia Pacific Law Review* 2
[119] Ibid.
[120] Ibid.
[121] Ibid.
[122] Ibid.
[123] UCL International Energy Policy Institute Adelaide, Australia, Shale Gas in Australia: The Policy Options, Green Paper, October 2013, pg 4 at https://www.ucl.ac.uk/australia/files/shale-gas-in-australia-green-paper-final

literature. The International Energy Policy Institute insisted that, in order for Australia to reach its development potential, its regulatory regimes must be reviewed and changed so as to provide a greater degree of 'clarity, transparency and community engagement'.[124] David Maloney argues that, given the likely significance of the shale gas industry in Australia, 'it is an appropriate time to evaluate the existing legislation to determine whether it is fit for purpose for shale gas exploitation or whether it lags best regulatory practice'.[125] As pointed out by Mr Maloney, 'there has been little legislative or policy attention to shale oil and shale gas, other than in the context of hydraulic fracturing…'[126]

There are four critical components to comparative methodology.[127] The first requires an evaluation of the law in a way that is clear, objective and neutral; the second is an evaluation that is expressed in a tangible way; the third requires an evaluation of the law in operation in a cultural context and lastly a summation of comparative observations.[128] The subsequent chapters will address each of these components. Comparing domestic law with foreign law is highly valued in doctrinal legal research.[129] It is also well known that legal practice now involves comparative law.[130]

In the United States, exploiting shale and tight gas has resulted in decreased unemployment, an increase in economic activity and has helped with energy independence.[131] Many want to know how to profitably exploit shale gas resources outside the United States.[132] Despite this, the Australia Institute argues against developing unconventional gas given 'gas is a small employer, unconventional gas development does not lead to cheaper gas prices, gas makes a small contribution to the state budget, gas has serious impacts on local communities and other industries'.[133] Some have suggested that, while there is significant investment potential for

[124] Ibid.
[125] David AW Maloney, 'Unconventional oil and gas in Australia: a case of regulatory lag' (2015) 33:4 *Journal of Energy & Natural Resources Law* 349, 353
[126] Id at 394.
[127] Edward J. Eberle, 'The Method and Role of Comparative Law', (2009) 8 *Wash. U. Global Stud. L. Rev.* 451, 457 http://openscholarship.wustl.edu/law_globalstudies/vol8/iss3/2
[128] Ibid.
[129] Mark Van Hoeke, 'Methodology of Comparative Legal Research', (2015) 1-35 *Law and Method* 1
[130] Ibid.
[131] Nicholson, Barclay and Blanson, Kadian, 'Trends emerge on hydraulic fracturing litigation' (2011) 109 *Oil & Gas Journal* 80
[132] Wang, Z. and Krupnick, A., A Retrospective Review of Shale Gas Development in the United States: What Led to the Boom?, 2013 at http://www.rff.org/RFF/Documents/RFF-DP-13-12.pdf
[133] Matt Grudnoff, Rod Campbell and Mark Ogge, Submission, The Australia Institute, Inquiry into Unconventional Gas (Fracking), February 2015

unconventional gas, the 'rapid growth elevates risks associated with environmental, social and governance (ESG) failures given the numerous unresolved technical, regulatory and stakeholder issues'[134] associated with exploiting unconventional gas. It is in the interests of investors that the risks and issues associated with exploiting unconventional gas are addressed early to limit potentially negative investment impacts.[135] Though it is quite difficult to understand exactly what the essential or necessary conditions for fostering the shale gas industry in Australia are, many commentators agree that an historic review of the United States experience, can at least inform the conditions that assisted in this regard.[136]

The understanding, expertise, and experience of operators, regulators, and academics in the United States in relation to the exploitation of shale and tight gas is extensive. Australia's acceptance of the comparative value of the United States is vitally important for future shale and tight gas exploitation in Western Australia and South Australia. Major technological advances have increased the viability of exploiting shale and tight gas with horizontal drilling techniques increasing the accessibility of unconventional deposits.[137] The use of horizontal drilling and hydraulic fracturing triggered a natural gas boom from shale formations in the United States and resulted in an average annual growth rate of nearly 50 percent in shale gas production.[138] Both these techniques can turn unproductive areas of the United States into large natural gas fields.[139]

There is substantial comparative value in examining how Colorado regulates shale and tight gas for various reasons. Australia and the United States have similar geological and industry conditions.[140] Dr Tina Hunter insists that Western Australia and South Australia's petroleum regulators are 'professional and have the necessary experience and processes to implement best

[134] Amanda Wilson, Regnan, Submission, Inquiry into the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas, 17 September 2013
[135] Ibid.
[136] Wang, Z. and Krupnick, A.,A Retrospective Review of Shale Gas Development in the United States: What Led to the Boom?, 2013 http://www.rff.org/RFF/Documents/RFF-DP-13-12.pdf
[137] CSIRO 'What is Hydraulic Fracturing?', Factsheet, 2012, CSIRO website, p. 1, viewed 5 December 2013, at < https://www.csiro.au/en/Research/Energy/Hydraulic-fracturing/a-What-is-hydraulic-fracturing>
[138] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 6 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF
[139] Hobart M. King, Hydraulic Fracturing of Oil & Gas Wells Drilled in Shale, (assessed 28 June 2017) at http://geology.com/articles/hydraulic-fracturing/
[140] EIA/ARI World Shale Gas and Shale Oil Resource Assessment, Australia, (2013), pg III-1 at https://www.eia.gov/analysis/studies/worldshalegas/pdf/Australia_2013.pdf

practice in the regulation of unconventional natural gas.'[141] According to Dr Simon Robb, Western Australia's regulatory approach 'is not optimal but it is coherent and anticipatory.'[142] The industry has changed so rapidly that Dr Robb argues that it has often outpaced the availability of information for regulators to develop specific guidance.[143] The United States offers important insights for Western Australia and South Australia as they seek to exploit shale and tight gas. This thesis believes Colorado represents an appropriate 'model' for duplication provided 'governance frameworks reflect domestic realities and capacities'.[144]

The success of the United States in exploiting natural gas has prompted investors to ramp up efforts to exploit Western Australia and South Australia's enormous shale and tight gas reserves. Colorado has considerable experience exploiting shale and tight gas and was the sixth leading producer state of natural gas in the United States in 2012.[145] It also has ten of largest natural gas fields in the United States.[146]

The author believes that Colorado has a regulatory regime that should be used as a regulatory model for Western Australia and South Australia. Dr Hawke AC received a number of submissions to his inquiry into hydraulic fracturing stating that Western Australia and South Australia have regulatory regimes that are bench marks for identifying best practice.[147] A number of the submissions also pointed to elements of Western Australia and South Australia's regulatory frameworks, as well as Colorado's, as being more appropriate.[148]

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[141] "WA DMIRS recognised as one of world's best resource regulators" Australian Mining news release 3 November 2013 from http://miningaustralia.com.au/news/wa-DMIRS-recognised-as-one-of-world-s-best-resources

[142] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, The University of Western Australia, 2014, pg 2

[143] Ibid.

[144] Jarvis, M, 'Towards a Roadmap for Governance of Unconventional Gas: A Multidimensional Challenge' (2014) 12:3 *Oil, Gas & Energy Law* at < https://www.ogel.org/article.asp?key=3464> (assessed 23 November 2017)

[145] Colorado State University, Oil and Gas Development in Colorado – 10.639 (2014) at http://extension.colostate.edu/topic-areas/family-home-consumer/oil-and-gas-development-in-colorado-10-639/

[146] Colorado State University, Oil and Gas Development in Colorado – 10.639, (2014) at < http://extension.colostate.edu/topic-areas/family-home-consumer/oil-and-gas-development-in-colorado-10-639/>

[147] Allan Hawke SC, Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory, (2014) at http://www.hydraulicfracturinginquiry.nt.gov.au/docs/report-inquiry-into-hydraulic-fracturing-nt.pdf

[148] Ibid.

While the author acknowledges that there are significant differences between the three regulatory regimes, (particularly given Colorado has a myriad of state, county, and federal government arrangements) there is sufficient cohesion between them to make a comparative analysis appropriate.[149] This thesis is underpinned by the principle that 'just as natural scientists use laboratories to conduct experiments to verify their own hypotheses, comparative law analysis acts as the laboratory for the legislator'.[150] The use of a comparative law methodology will achieve the thesis objective, that is, to improve Western Australia and South Australia's regulatory regimes.[151]

The author acknowledges that there are no guarantees that Western Australia and South Australia have the capacity to replicate what has occurred in Colorado. However, some industry commentators suggest that there is '…much merit in sharing knowledge and experience between the United States and Australia in the development of unconventional gas production, and building on the lessons learned in the United States could improve regulation and governance in Australia'.[152] The regulatory regime in the United States is complex.[153] Some suggest that this is the result of it 'having to 'catch up' to the rapid increase in shale gas activity and the interaction between federal and state governments'.[154]

There is widespread concern with the use of hydraulic fracturing. Some argue that Colorado 'is at the forefront of policy-making and public debate over the regulation of hydraulic fracturing'.[155] Colorado was the first jurisdiction in the United States to pass wide-ranging rules dealing with the public disclosure of chemicals that are used in hydraulic fracturing.[156]

[149] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 47 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF
[150] Mauro Cappellatti, 'Comparative Law Teaching and Scholarship: Method and Objectives' (1994) *Asia Pacific Law Review* 7
[151] Mark Van Hoecke, 'Methodology of Comparative Legal Research' (2015), Law and Method, 2
[152] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 47 at < https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF>
[153] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, The University of Western Australia, 2014, pg 2
[154] Ibid.
[155] Austin Shaffer, Skylar Zilliox & Jessica Smith 'Memoranda of understanding and the social licence to operate in Colorado's unconventional energy industry: a study of citizen complaints' (2017) 35:1 *Journal of Energy & Natural Resources Law* 69, 70
[156] Tanya Heikkila and others, 'Understanding a Period of Policy Change: The Case of Hydraulic Fracturing Disclosure Policy in Colorado' (2014) 31 *Review of Policy and Research* 65

Colorado's framework is entrenched, development is at an advanced stage and it has some of the most restrictive regulations on oil and gas production in the United States.[157] Some industry commentators suggest that Colorado has the toughest groundwater monitoring rules, requirements for post line testing for gas wells and restrictive stormwater rules.[158]

Colorado has significant experience exploiting shale and tight gas and a relatively mature state based regulatory regime administered by the Colorado Oil and Gas Conservation Commission (COGCC). The author believes that Western Australia and South Australia will both face the same risks and challenges experienced by communities, politicians and industry in Colorado though in a vastly different social and political context. One industry commentator contends, quite correctly, that 'there is no cookie cutter approach' and that it is important for operators to understand the political economy in which they operate.[159]

The COGCC has taken steps to address stakeholder concerns with hydraulic fracturing by imposing additional regulatory requirements that deal with hydraulic fracturing.[160] There are key provisions in Colorado that are transferable to Western Australia and South Australia that should be transferred as a priority. For example, Western Australia and South Australia do not do enough to protect landowners by minimising intrusion on private land by operators. This is often justified because both are mining states. Operators can essentially (subject to conditions) mine anywhere except in certain restricted areas, for example, national parks and people's houses. In Western Australia and South Australia, landowners and operators can enter into land access agreements that have no statutory basis. These agreements are voluntary and drafted with reference to non-statutory guidelines. There is a statutory provision in Colorado known as 'reasonable accommodation' that sets out that operators and landowners should seek to minimise intrusion on land.

[157] Stephanie Neitzel, P.E. Esq, Water Quality Regulations for Unconventional Gas Production United States and Australia Comparison, WaterRich Advisors LLC, at < http://www.awa.asn.au/documents/136%20SNeitzel.pdf> (assessed 20 July 2017)
[158] Ibid.
[159] Jarvis, M, 'Towards a Roadmap for Governance of Unconventional Gas: A Multidimensional Challenge', (2014) 12:3 *Oil, Gas & Energy Law* < https://www.ogel.org/article.asp?key=3464> (assessed 23 November 2017)
[160] COGCC Hydraulic Fracturing Rules, at https://cogcc.state.co.us/Announcements (assessed 20 June 2016)

The significant differences between how Western Australia, South Australia and Colorado regulate shale and tight gas exploitation cannot simply be rationalised on the basis of the differences in geology, hydrology, and demographics, because the regulatory issues present different risks to local communities and industry.[161] Most are nothing more than ad hoc modifications that have occurred over decades.[162] The author argues that the differences between each of the regimes is the result of political motives, community acceptance and the control, influence and the knowledge held by their respective regulatory agencies.

This thesis argues that Western Australia and South Australia cannot simply take a 'wait and see' approach to shale and tight gas exploitation because they are in the early stages of exploration.[163] Both jurisdictions should continue to explore for, and exploit, shale and tight gas though regulators, operators and communities must commit to a prolonged discussion of the accompanying risks and challenges and formulate policies and introduce laws that might address them. Each of these groups must examine the risks and impacts over time as part of the overall exploration, production and abandonment process.

The mixture of different regulatory regimes and approaches is driven by the regulatory goals of the respective jurisdictions and their desire to achieve them, plus the motivation of the respective regulatory bodies and government. The United States has considerable experience, expertise, and knowledge in producing shale and tight gas and it has been suggested that 'in terms of governance and regulation, the complexity of operating within state, county, and federal government arrangements – while very different in detail – have much in common between the United States and Australia.'[164]

The author argues that a considerable amount can be gained if Western Australia and South Australia examine how Colorado regulates shale and tight gas exploitation in several key areas. Western Australia and South Australia should modify their regulatory regimes accordingly, not

[161] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, and Hannah Wiseman, The State of State Shale Gas Regulation, Executive Summary, May 2013, pg 5
[162] Ibid.
[163] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, The University of Western Australia, 2014, pg 66
[164] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 47 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF

least because it is likely that Australia is poised to become one of the next major shale and tight gas producing countries.

This thesis will compare Western Australia's *Petroleum and Geothermal Energy Resources Act 1967* (WA) (PGERA) and South Australia's *Petroleum and Geothermal Act 2000* (SA) (PGEA) to Colorado's *Oil and Gas Conservation Act (Colo. Rev. Stat. § 34-60-100, et seq.)* (OGCA). It will also examine Western Australia's *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) (PGERA Environment Regulations), *Petroleum and Geothermal Energy Resources (Resources Management and Administration) Regulations 2015* (WA) (PGERA Administration Regulations) and South Australia's *Petroleum and Geothermal Energy Regulations 2013* (SA) (PGER) to Colorado's Oil and Gas Conservation Commission Rules (COGCC rules).

1.7 Legislative intent

The PGERA and PGEA have a slightly different focus to the OGCA. The PGERA and PGEA contain no clear and unequivocal statement of legislative intent with regard to the exploitation of shale and tight gas, which is not surprising given they were both drafted with conventional gas in mind. The different regulatory approaches and legislative focus is one of the reasons both the PGERA and PGEA are deficient in certain areas.

The PGERA deals with 'the exploration for, and the exploitation of, petroleum resources, geothermal energy resources, and certain other resources, within certain lands of the State...'[165] and the PGEA covers the 'exploration for, and the recovery or commercial utilisation of, petroleum and certain other resources; and for other purposes.'[166] In stark contrast, the legislative declaration of the OGCA states, amongst other things, that 'it is declared to be in the public interest to: Foster the responsible, balanced development, production, and utilization

[165] *Petroleum and Geothermal Energy Resources Act 1967* (WA), Long title
[166] *Petroleum and Geothermal Energy Act 2000* (SA), Long title

of the natural resources of oil and gas in the state of Colorado in a manner consistent with protection of public health.'[167]

The COGCC operates in a similar way to the DMIRS and South Australia's Department of Premier and Cabinet (DPC) in that it promotes exploration, development, and conservation of gas, controls drilling and hydraulic fracturing permit processes and ensures operators comply with state-wide gas statutes and regulations. However, the PGERA and PGEA do not explicitly emphasise the role played by DMIRS or DPC respectively. By comparison, the OGCA explicitly empowers the COGCC to 'prevent the escape of oil or gas from one stratum into another, the intrusion of water into oil or gas stratum, the pollution of fresh water supplies by oil, gas, salt water, or brackish water.'[168] The OGCA states that the COGCC regulates 'oil and gas operations so as to prevent and mitigate significant adverse environmental impacts on any air, water, soil, or biological resource resulting from oil and gas operations to the extent necessary to protect public health, safety, and welfare, including protection of the environment'.[169]

The COGCC fosters reliable, balanced development, production, and utilisation of oil and gas in Colorado.[170] The COGCC's role expanded in the early 1990's and it began to consider the environmental impacts and public health, safety and welfare.[171] The COGCC administers rules and regulations and has operational standards and requirements for industry activity.[172] The differences go much further that mere legislative intent. The COGCC 'provides rules and regulations to establish operational standards and requirements for industry activity in the state.'[173]

In 2007, Colorado's General Assembly enacted House Bill 1341 which elevated the protection of the environment as a key role for the COGCC. The legislative declaration at the beginning

[167] *Oil and Gas Conservation Act* (Colorado), § 34-60-102(1)(a)(i)
[168] *Oil and Gas Conservation Act* (Colorado), §34-60-106(c)
[169] *Oil and Gas Conservation Act* (Colorado), §34-60-106,
[170] *Oil and Gas Conservation Act* (Colorado), § 34-60-102(1)(a)(i)
[171] *Chase v. Colo. Oil & Gas Conservation Comm'n*, 2012 COA 94M, 25, 284 P.3d 161, 165-66 (Colo. App. 2012).
[172] Colorado Oil & Gas Conservation Commission, at https://cogcc.state.co.us/reg.html#/overview (assessed 23 May 2017)
[173] Ibid

of the OGCA was revised to declare it to be in the public interest to foster 'responsible, balanced' development of oil and gas in a manner not only consistent with the protection of public health, safety and welfare, but also the protection of the environment.[174] The Colorado Supreme Court recently announced that it would review the Colorado Court of Appeals ruling in *Martinez v. Colorado Oil & Gas Conservation Commission*, a challenge to the authority of the COGCC authority to issue new oil and gas drilling permits.[175]

In 2013, a number of teenagers, including Martinez, asked the COGCC not to issue new oil and gas drilling permits unless it could be done in a way that does not ' impair Colorado's atmosphere, water, wildlife, and land resources, does not adversely impact human health and does not contribute to climate change'.[176] For many years, the COGCC interpreted the OGCA so as to balance production with other policy objectives.[177] Previous court decisions determined that the OGCA required the COGCC to consider an assortment of policies when making decisions.[178] The court of appeals rejected the COGCC's long held interpretation and determined that the COGCC could disregard the OGCA's directive to foster responsible oil and gas development and enact rules that would prohibit oil and gas related activity unless they occurred with zero environmental impact.[179]

1.8 Thesis structure

Chapter 2 of this thesis provides some context for the comparative regulatory analysis. It is divided into two sections. The chapter defines unconventional gas, with a particular focus on shale and tight gas, and examines the production stages and production methods required to exploit shale and tight gas, the footprint of shale and tight gas operations and resource classifications. The chapter also summarises Australia's shale and tight gas prospectivity.

[174] Colorado Oil and Gas Conservation Commission , A Decade of Change: COGCC Policy, Regulation, Transparency - 2007-2017, http://cogcc.state.co.us/documents/about/Summary_COGCC_RM_2007_2018.pdf
[175] *Martinez v. Colo. Oil and Gas Conservation Comm'n*, 2017 COA 37
[176] *Martinez*, Colorado Court of Appeals, Court of Appeals No. 16CA0564, City and County of Denver District Court No. 14CV32637, pg 3
[177] Colorado Oil and Gas Conservation Commission's Petition for Writ of Certiorari, Case No: 17 SC 297, pg 1
[178] Ibid.
[179] Ibid.

Chapter 2 also summarises the role of water, volume required and availability in Australia in the context of the exploitation of shale and tight gas. The remainder of Chapter 2 encompasses a literature review that focuses on the community concerns with shale and tight exploitation and the key regulatory issues.

Chapter 3 provides a brief history of mineral and petroleum ownership, which includes an examination of indigenous rights. The chapter also examines regulatory approvals focusing on environmental approvals and assessment. Chapter 3 also examines the various regulatory approaches that can be used to manage the exploitation of shale and tight gas.

Chapter 4 comprises a comparative analysis of the regulatory issues. The chapter examines, amongst other things, access agreements, water trigger and the state based water legislation of the three jurisdictions. It also examines public disclosure of chemicals and Colorado's reclamation regulations.

Chapter 5 summarises the gaps that exist in Western Australia and South Australia concerning land access, water access and quality protection, regulation of well technology for drilling and hydraulic fracturing and decommissioning and associated issues. This chapter presents a number of recommendations that should be implemented by Western Australia and South Australia to fill the gaps in their regulatory regimes.

1.9 Conclusion

Western Australia, South Australia and Colorado have very diverse regulatory regimes to manage the exploitation of shale and tight gas. This is not unexpected. While regulatory diversity is common and not a significant problem, the question of whether it is appropriate depends largely on whether it is embedded in underlying differences.[180] There are particular aspects of shale and tight gas regulatory regimes that the author believes should not be handled

[180] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, and Hannah Wiseman, The State of State Shale Gas Regulation, Executive Summary, May 2013, pg 5

in a different way merely because exploitation is occurring in a different jurisdiction, even if the jurisdiction is outside Australia.

The way in which jurisdictions regulate the exploration, production and abandonment of shale and tight gas is clearly more heterogenous than homogenous.[181] This is particularly the case when Western Australia and South Australia's regulatory regimes are compared to Colorado. The 'heterogeneity of shale gas regulations is widespread and it can be seen in what states regulate and how stringently they do so'.[182] The differences in regulation may well reflect the fundamental differences of geology, hydrology, demographics, or other issues that affect the local risks to the industry or unplanned variation that has occurred over decades of regulation.[183] Regulators can benefit from prolonged research into the sources of heterogeneity to ensure that they are making decisions that adequately protect the public and the environment.[184]

The author contends that the PGERA and PGEA lack a number of key provisions when they are compared to the OGCA. The OGCA is succinct and complimented by detailed and easily digestible COGCC rules. The COGCC rules and regulations establish operational standards and requirements for industry activity in Colorado.[185] There are numerous COGCC rules that should be considered by Western Australia and South Australia for inclusion in the PGERA and PGEA respectively.

The remaining chapters of the thesis will examine whether the PGERA and PGEA lack favourable regulations that address, amongst other things, land access, water use, drilling, well integrity and rehabilitation. The author contends that the PGERA and PGEA do not adequately protect underground, surface or drinking water and lack key features which, if included, would make them effective at regulating shale and tight gas exploitation.

[181] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, The University of Western Australia, 2014, pg 84
[182] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, and Hannah Wiseman, The State of State Shale Gas Regulation, Executive Summary, May 2013, pg 5
[183] Ibid
[184] Ibid
[185] Colorado Oil & Gas Conservation Commission at https://cogcc.state.co.us/reg.html#/overview

The result of undertaking a comparative analysis into the regulatory regimes in Western Australia, South Australia and Colorado will be the identification of a number of provisions within the OGCA and COGCC rules for managing the issues identified in this introduction.

The thesis has chosen not to consider how the Paris Agreement[186] commitments may, or may not, impact Western Australia and South Australia's expectations of developing shale and tight gas. Several years ago, the United Kingdom government approved hydraulic fracturing in Lancashire and some in the community suggested that the government was making a statement that the government was not interested in abiding by 'either the spirit or the maths of the Paris agreement.'[187] The same question may be asked in Australia when governments approve the development of the shale and tight gas industry but that question is not answered in this thesis.[188]

[186] United Nations Framework Convention on Climate Change, The Paris Agreement, (2018) at http://unfccc.int/paris_agreement/items/9485.php

[187] Letters, In their clamour for shale gas, ministers forgot the climate agreement, *The Guardian*, (16 October 2016 at https://www.guardian.com/environment/2016/oct/16/in-their-clamour-for-shale-gas-ministers-forgot-the-climate-agreement

[188] Sangita Bista, Philip Jennings and Martin Anda, 'Cradle to grave GHG emissions analysis of shale gas hydraulic fracking in Western Australia' (2017) 2:45 *Renew. Energy Environ. Sustain*. 2, 2

2 CONTEXT FOR THE COMPARATIVE REVIEW

Some suggest this shale gas boom is a bridge to a more sustainable energy future that provides abundant and geologically distributed energy with environmental advantages relative to current alternatives such as coal. Others view the environmental impacts from shale gas development, on water resources in particular, as being too uncertain and risky.[189]

2.1 Introduction

Shale and tight gas exploitation 'has sparked considerable debate in many parts of the world and has often been described as a geopolitical game changer.'[190] It has emerged as a significant energy source in the United States and has been described by various industry commentators as a 'revolution'[191], 'a paradigm shift'[192] , a 'boom'[193] and a 'golden age.'[194] Some have suggested that Australia is currently in the midst of its own 'shale gale.'[195] Australia's first shale gas assessment project was conducted in the Cooper Basin in 2006.[196] The first vertical well targeting shale gas was drilled in the Cooper basin in 2010.[197] By December 2012, a minimum of nine 'plays' were being explored by more than 20 joint ventures.[198] Initial well flow rates ranged from 1.000 million cubic feet per day (mmcf/d) to 2.600 mmcf/d.[199] These

[189] Rahm, B, G and Riha, S, J, 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci: Processes Impacts* 1400, 1409 at <http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H>

[190] Jonas Teusch, 'Shale Gas and the EU Internal Gas Market: Beyond the hype and hysteria' (EPS Working Document No. 369, (September 2012) 1-12

[191] D Brooks, 'Shale Gas Revolution', *New York Times*, 3 November 2011. Available at: http://www.nytimes.com/2011/11/04/opinion/brooks-the-shale-gas-revolution.html Viewed 20 January 2015.

[192] P Cook, V Beck, D Brereton, R Clark, B Fisher, S Kentish, J Toomey and J Williams, Engineering Energy: Unconventional Gas Production, Report for the Australian Council of Learned Academies, May 2013, p 35 (referred to in this report as the ACOLA Report).

[193] President Barack Obama, The White House, Office of the Press Secretary, Remarks by the President in State of the Union Address, 12 February 2013. Available at: http://www.whitehouse.gov/the-pressoffice/2013/02/12/remarks-president-state-union-address

[194] International Energy Agency, Golden Rules for a Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, 2011, pg 47 at http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf

[195] Robertson, S, "Unconventional Gas – Legal Issues' (2012) *AMPLA Yearbook* 311

[196] DMITRE, "Roadmap for Unconventional Gas Projects in SA" (2012), Ch 4.

[197] UCL International Energy Policy Institute Adelaide, Australia, Shale Gas in Australia: The Policy Options, Green Paper, October 2013 at https://www.ucl.ac.uk/australia/files/shale-gas-in-australia-green-paper-final

[198] Inquiry into Unconventional Gas (Fracking) Interim report, Parliament of SA, (2015), pg 14

[199] Ibid.

rates are similar to those in the United States.[200] The government of South Australia estimates that the Cooper Basin will reach 2500 shale wells in total by 2028, recovering some 6.0 trillion cubic feet (tcf) of gas.[201] The state's first commercial shale gas development was initiated by Santos with the Moomba-191 vertical shale well.[202] The BG Group obtained shale interests from Drillsearch in 2011 and in 2013, Chevron agreed to fund exploration operations to gain a stake in petroleum titles from Beach Energy.[203] Beach Energy, Drillsearch Energy, Senex Energy, Strike Energy and Icon Energy are currently assessing shale potential in the Cooper Basin.[204]

In Western Australia, there is significant activity in the Canning Basin, led by Buru and New Standard Energy.[205] Buru entered into a 'farm-out' agreement with Mitsubishi in June 2010.[206] In November 2013, Apache Energy joined the Buru/Mitsubishi joint venture.[207] In June 2014, the DMIRS approved Buru's Laurel Formation Tight Gas Pilot Exploration programme, which set out to identify the potential environmental impacts and risks associated with exploration.[208] The programme involved stimulating tight gas zones in existing vertical exploration wells to assess marketable potential.[209] Since 2005, 17 exploration wells have been drilled in Western Australia looking for shale and tight gas.[210] Seven of these were fractured, with six in the Perth Basin and one in the Canning Basin.[211] The most recent well to undergo fracking was in August 2015 (figure as at July 2015).[212]

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[200] Lippman Consulting Inc, Lower 48 states shale initial production report, 2011

[201] Department for Manufacturing, Innovation, Trade, Resources and Energy, SA Roadmap for unconventional gas projects in SA, Government of SA: Energy Resources Division, Department for Manufacturing, Innovation, Trade, Resources and Energy, 2012 at <http://petroleum.statedevelopment.sa.gov.au/__data/assets/pdf_file/0019/238033/Roadmap_Unconventional_Gas_Projects_SA_12-12-12_web.pdf>

[202] UCL International Energy Policy Institute Adelaide, Australia, Shale Gas in Australia: The Policy Options, Green Paper, October 2013 at https://www.ucl.ac.uk/australia/files/shale-gas-in-australia-green-paper-final

[203] Liz Allnutt, Australia: Shale gas handbook for Australia, Norton Rose Fulbright Australia, 2015 at http://www.mondaq.com/australia/x/409972/Oil+Gas+Electricity/Shale+gas+handbook+for+Australia

[204] Ibid.

[205] Ibid.

[206] Buru Energy at http://www.buruenergy.com/company-overview-buru-energy/our-history/ (accessed 21 June 2017)

[207] Ibid.

[208] Ibid.

[209] Ibid.

[210] Department of Mines, Industry Regulation and Safety, Shale and tight gas exploration in Western Australia at http://www.dmp.wa.gov,au/Petroulem /Shale-and-tight-gas-exploration-19990.aspx , (accessed 13 May 2017)

[211] Ibid.

[212] Ibid.

This chapter broadly outlines the key characteristics of unconventional gas and then provides a definition of shale gas and tight gas. The chapter examines the methods used to exploit shale and tight gas, namely, horizontal drilling and hydraulic fracturing and provides the reader with an understanding of the surface footprint of shale and tight gas operations in terms of well numbers, surrounding land, infrastructure and ground and surface water impacts. The chapter examines Australia and Colorado's reserves and basins, sets out the resource classification types and examines Western Australia and South Australia's shale and tight gas prospectivity. It also considers the role water plays in developing shale and tight gas and surveys the likely impact in, and around the Great Artesian Basin and Canning Superbasin. The chapter also includes a literature review that sets out a number of community concerns and regulatory issues.

2.2 Shale gas, tight gas and water

It is important to note that the gas in conventional basins has the same composition as the gas in unconventional basins.[213] Unconventional gas is a fossil fuel that contains up to 90 percent methane with the balance consisting of ethane, propane, butane, carbon dioxide, oxygen, nitrogen, hydrogen sulphide and trace amounts of other gases.[214] It is porous and its low-permeability features act like a *sponge*.[215] It is the complicated production methods that are required to extract shale and tight that also differentiate conventional gas from unconventional gas.[216]

Unconventional gas is sourced from geological formations.'[217] These consist of rock strata that have a similar lithology, facies or other similar properties.[218] Geological formations play a

[213] CSIRO, What is conventional and unconventional gas? (25 February 2015) at https://www.csiro.au/en/Research/Energy/Hydraulic-fracturing/What-is-unconventional-gas ; AWE, What is conventional and unconventional gas? at http://www.awemidwest.com.au/how-we-produce-gas/shale-tight-coal-seam-gas/ (accessed 29 June 2017)

[214] Natural Gas, AMMA, Resource Industry Employer Group (accessed 15 May 2016), at http://www.miningoilgasjobs.com.au/oil-gas-energy/hydrocarbons-and-energy/hydrocarbons/oil-and-gas/downstream/natural-gas.aspx,

[215] Burwen, J & Flegel, J, Unconventional Gas Exploration & Production, Case studies on the Government's role in Energy Technology Innovation, March 2013, page 1-3 at http://americanenergyinnovation.org/wp-content/uploads/2013/03/Case-Unconventional-Gas.pdf

[216] Shale Gas Information Platform, Basics of Shale Gas, (accessed 18 May 2017) at http://www.shale-gas-information-platform.org/areas/basics-of-shale-gas.html

[217] Department of Industry, Innovation and Science, Unconventional gas, what is it? (accessed 18 May 2016) at https://industry.gov.au/resource?Upstream

[218] Utah Geological Survey, What is a Formation? (accessed 23 May 2017) at https://geology.utah.gov

role in the exploration and production of petroleum and they have significant consequences for licensing regimes.[219] Shale and tight gas exploitation often requires operators to drill large numbers of wells in large production areas, areas that are usually much larger than for conventional reservoirs.[220]

The complex geological systems that contain unconventional gas make it quite hard to exploit, requiring relatively new technological solutions, namely, horizontal drilling and hydraulic fracturing.[221] The composition of the rock containing the gas prevents it from migrating and results in an absence of reservoirs or collective pools.[222] A pool is 'an underground reservoir containing a common accumulation of oil or gas, or both'.[223] According to the United States Department of Energy, 'in a conventional reservoir, the gas is interconnected pore spaces, much like a kitchen sponge, that allow easier flow to a well; but in an unconventional reservoir, like shale, the reservoir must be mechanically "stimulated" to create additional permeability and free the gas for collection.'[224]

[219] John Chandler, 'Shale gas and government agreements in WA' (2014) 33 *ARELJ* 44, 46
[220] John Chandler, 'Shale gas and government agreements in WA' (2014) 33 *ARELJ* 44, 46
[221] CSIRO, What is unconventional gas? at http://www.csiro.au/en/Research/Energy/Hydraulic-fracturing/What-is-unconventional-gas
[222] John Chandler, 'Shale gas and government agreements in WA' (2014) 33 *ARELJ*
[223] OGCA, definitions, (9) 'Pool'
[224] Natural Gas From Shale: Questions and Answers, How is Shale Gas Produced at < https://www.energy.gov/sites/prod/files/2013/04/f0/how_is_shale_gas_produced.pdf>

The various permeability types can be seen in the following diagram:

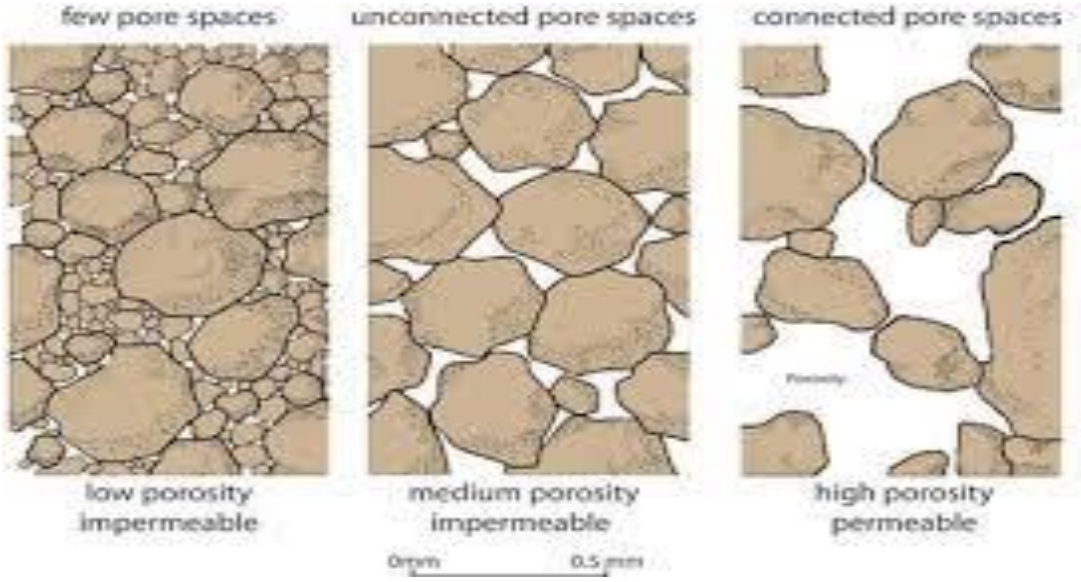

Figure 1 Low porosity- impermeable rock to high porosity-permeable rock[225]

Shale gas is trapped in shale formations[226] characterised by low permeable sedimentary rock[227] at depths between 2000 and 5000 metres.[228] This type of gas is more difficult to produce than coal seam gas given shale is much harder, more impermeable and typically found deep underground.[229] Shales are usually found in source rock where there has been no migration of

[225] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Government Approach, 2015 Edition at http://www.DMIRS.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf

[226] United States Energy Information Administration, Geoscience News & Information, Energy in Brief (2010), What is Shale Gas? at http://geology.com/energy/shale-gas/

[227] Catriona, Dr R, 'Unconventional Gas: Coal Seam Gas, Shale Gas and Tight Gas, An introduction and overview of issues relevant to the development of unconventional gas in Victoria', Parliament of Victoria, (December 2013)

[228] Department of Mines, Industry Regulation and Safety, Natural Gas from Shale and Tight Rocks, 'An overview of Western Australia's regulatory framework', February 2014 at http://www.DMIRS.wa.gov.au/documents/Natural_Gas_from_Shale_and_Tight_Rocks_-_An_overview_of_Western_Australia_regulatory_framework.pdf

[229] J. Rutovitz, S. Harris, N. Kuruppu and C. Dunstan Drilling Down. Coal Seam Gas: A Background Paper, November, prepared by Institute for Sustainable Futures UTS for the City of Sydney Council, 2011 pg 3

petroleum resulting in the absence of a reservoir or pool.[230] Shales are so impermeable that hydraulic fracturing is essential to enable the gas to flow.[231] Large amounts of water are required to exploit shale gas compared to coal seam gas.

Shale gas exploitation does not produce the large amounts of water compared to the coal seam gas dewatering process.[232] Tight gas is found in rock (often sandstone but also carbonate)[233] with very low permeability at depths of between 2000 and 5000 metres.[234] The holes between the rocks containing tight gas are very small and the interconnections between them so narrow that the gas migrates with great difficulty.[235] Large amounts of water are needed to extract tight gas via hydraulic fracturing.

[230] Ibid
[231] Ibid
[232] Cook, P, Beck, V, Brereton, D, Clark, R, Fisher, B, Kentish, S, Toomey, J and Williams, J (2013). Securing Australia's Future – Engineering energy: unconventional gas production,pg 29 at http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-6
[233] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Government Approach, 2015 Edition, pg 6 at http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/3913541ae03e783bf52cf5b948257ee5000a9d20/$file/3541.pdf
[234] Department of Mines, Industry Regulation and Safety, Shale and Tight Gas in Western Australia: An overview of Western Australia's regulatory framework, August 2016 at < http://www.dmp.wa.gov.au/Documents/Petroleum/Shale_and_Tight_Gas_overview.pdf>
[235] Catriona, Dr R, 'Unconventional Gas: Coal Seam Gas, Shale Gas and Tight Gas, An introduction and overview of issues relevant to the development of unconventional gas in Victoria', Parliament of Victoria, (December 2013)

The following diagram shows the geology of natural gas reserves:

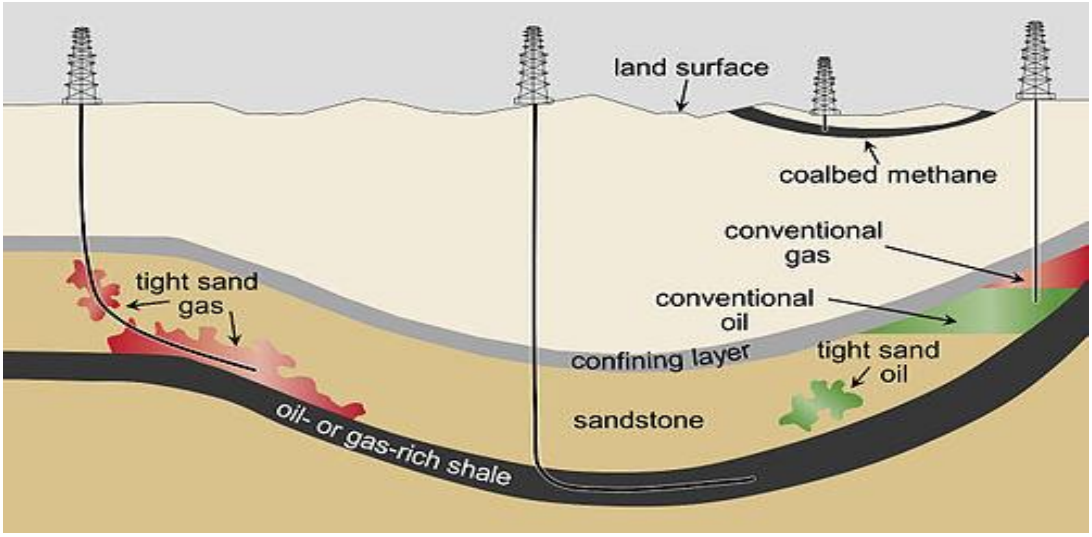

Figure 2 Schematic geology of natural gas resources[236]

The far right vertical well is producing gas from a conventional oil and gas deposit. The grey layer (the confining layer) traps oil (green) or gas (red). The well second from the right is producing gas from unconventional formations: a vertical coal bed methane well. A horizontal well (centre) is producing from a shale formation and a well is producing from a tight sand formation (left). The difference between conventional gas and unconventional gas is not chemical composition (given it is all natural gas), but rather the result of the geological characteristics and location.[237]

[236] Intermountain Oil and Gas BMP Project, the Colorado Rural Water Association, AirWaterGas and Western Resource Advocates, Protecting source water in Colorado during oil and gas development, August 2016, pg 1 at http://www.oilandgasbmps.org/docs/CO186_ProtectingSourceWaterAugust2016.pdf

[237] Total, Three main sources of unconventional gas, (accessed 12 May 2016) at http://www.total.com/en/energies-expertise/oil-gas/exploration-production/strategic-sectors/unconventional-gas/presentation/three-main-sources-unconventional-gas

2.2.1 Production stages and production methods: Drilling and fracturing

Operators typically 'exercise the right to control the conduct of oil and gas operations.'[238] They undertake exploration, production and abandonment activities.[239] During exploration they carry out drilling, seismic surveys, sample shale rock and flow testing.[240] They also assemble well pads, install drilling rigs and normally transport equipment, water and chemicals to and from well sites. During production operators are likely to increase their drilling activities and commence hydraulic fracturing.[241] They may also remove water from sites for treatment and disposal. During the production phase operators typically carry out maintenance activities and drill additional wells (this level of activity is likely to decline over time). The final stage of exploitation involves restoring sites to their original condition. Operators must ensure wells are safe for abandonment and remove wells pads and drilling rigs. Well decommissioning and restoration activities can occur at any time if operators choose not to move from exploration to production.[242]

Horizontal drilling (also known as directional drilling or deviated drilling) involves operators transferring a wells path from vertical to horizontal.[243] Horizontal drilling has been described as a process where a 'wellbore is drilled vertically to a kick-off depth above the target formation and then angled through a wide ninety degree arc so that the producing portion of the well extends horizontally through the target formation'.[244]

[238] COGCC rules and regulations, definitions (100 series)
[239] Frogtech Pty Ltd, Potential Geological Risks Associated with Shale Gas Production in Australia, Melbourne: Australian Council of Learned Academics, 2013 pg 2 at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf
[240] Stephenson Halliday, Environmental Planning, Landscape Architecture, Planning Advisory Service, Planning for Shale Gas and Oil – Briefing note March 2016, pg 6 at https://www.local.gov.uk/sites/default/files/documents/shale-gas-and-oil-explora-471.pdf
[241] Ibid.
[242] Ibid.
[243] The Australian Petroleum Production and Exploration Association, Horizontal drilling, (accessed 12 August 2016) at http://www.appea.com.au/oil-gas-explained/operation/horizontal-drilling/
[244] Canadian Society of Unconventional Resources, 'Understanding Water and Unconventional Resources' (Information Booklet) 22, (accessed 14 July 2017) at http://www.csur.com/sites/default/files/Undertsnding_Water_final_pdf

The use of horizontal drilling has reduced surface impacts and improved production.[245] This is the result of greater contact with the productive strata of reservoirs.[246] The technological advances that have occurred have enabled operators to drill gas formations and redirect drills through gas-bearing areas enabling up to six wells to be operated from one surface drilling pad.[247]

The following diagram shows vertical and horizontal drilling:

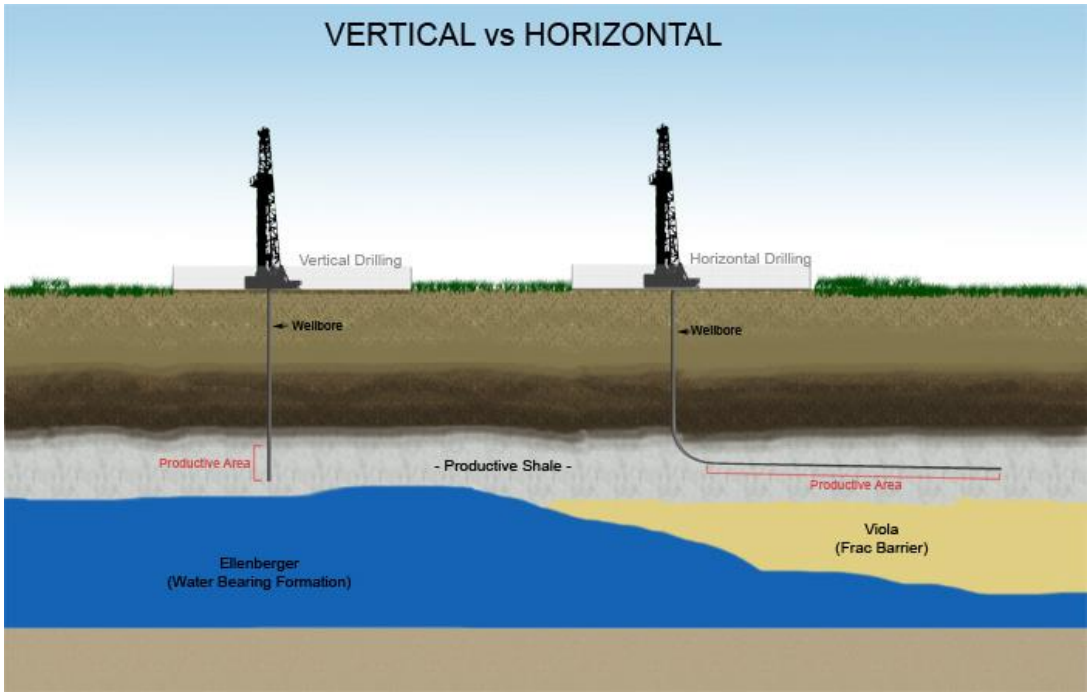

Figure 3 Vertical vs Horizontal drilling[248]

[245] The Australian Petroleum Productions and Exploration Association, Horizontal drilling, (accessed 15 June 2017) at http://www.appea.com.au/oil-gas-explained/operation/horizontal-drilling/

[246] Burwen, J & Flegel, J, Unconventional Gas Exploration & Production, Case studies on the Government's role in Energy Technology Innovation, March 2013, page 1-3 at http://americanenergyinnovation.org/wp-content/uploads/2013/03/Case-Unconventional-Gas.pdf

[247] Shale gas in Australia, Hydraulic fracturing, (accessed 21 May 2017) at http://www.shale-gas.com.au/industry-operations/hydraulic-fracturing/

[248] Keystone Exploration, Vertical vs Horizontal drilling, (accessed 13 June 2017) at http://www.kx-kp.com/?page=drilling&type=natural_gas

Hydraulic fracturing is a process of well stimulation post drilling.[249] The process involves injecting fluid at high pressure into wells and target rock to produce fractures a few millimetres wide that extend hundreds of metres.[250] This enables fluid to fill the fractures to keep them from resealing allowing the gas to flow into the well for extraction.[251] Hydraulic fracturing has increased the productivity of shale and tight gas wells.[252] Wells are fractured continually over the course of an operation as fractures reseal naturally over time.[253] Typically wells have a valuable production life of 20 – 40 years, and should be re-fractured every three to five years so they continue to have an economically viable production flow.[254]

Hydraulic fracturing fluid comprises water, sand and chemicals. The volume of water, which is almost 100 percent of the fluid, varies from project to project and on the size and length of the well, and the type of rocks being fractured.[255]

[249] American Society of Civil Engineers, Policy Statement 539 – Hydraulic Fracturing, 20 July 2012 at http://www.asce.org/Public-Policies-and-Priorities/Public-Policy-Statements/Policy-Statement-539---Hydraulic Fracturing/

[250] Jackson RB, Rainey Pearson B, Osborn SG, Warner NR and Vengosh A, *Research and Policy Recommendations for Hydraulic Fracturing and Shale-Gas Extraction* (Centre on Global Change, Duke University, Durham NC, 2011).

[251] Burwen, J & Flegel, J, Unconventional Gas Exploration & Production, Case studies on the Government's role in Energy Technology Innovation, March 2013, page 1-3 at http://americanenergyinnovation.org/wp-content/uploads/2013/03/Case-Unconventional-Gas.pdf

[252] Australian Petroleum Production & Exploration Association 'Hydraulic Fracturing', 2013, APPEA website, viewed 12 September 2013.

[253] Burwen, J & Flegel, J, Unconventional Gas Exploration & Production, Case studies on the Government's role in Energy Technology Innovation, March 2013, page 1-3 at http://americanenergyinnovation.org/wp-content/uploads/2013/03/Case-Unconventional-Gas.pdf

[254] Hoffman, A., Olsson, G., Lindstrom, A. 2014. Shale and Hydraulic Fracturing: Framing the Water Issue. Report Nr 34. SIWI, Stockholm, pg 18

[255] Department of Mines, Industry Regulation and Safety, Natural Gas from Shale and Tight Rocks, An overview of Western Australia's regulatory framework, (accessed 15 June 2017) at http://www.DMIRS.wa.gov.au/documents/Natural_Gas_from_Shale_and_Tight_Rocks_-_An_overview_of_Western_Australia_regulatory_framework.pdf

The below diagram shows a horizontal well and hydraulic fracturing:

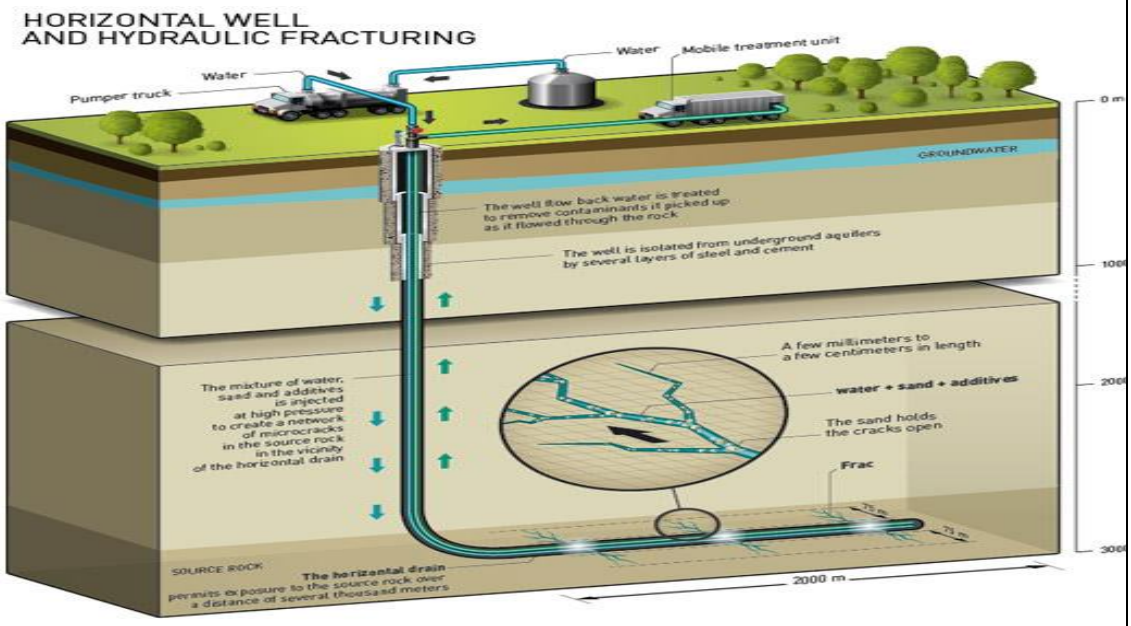

Figure 4 Horizontal well and Hydraulic Fracturing[256]

2.2.2 Footprint – shale gas, tight gas and water

The footprint of a shale and tight gas operation can be, but is not exclusively, defined by the number of wells and surrounding land and infrastructure operators require for exploration, production and abandonment and by the environmental impacts, for example, the impact on ground and surface water.[257] The priority for operators should be, and often is, the minimisation of the impacts on, amongst other things, the land it uses and the water resources it exploits to reduce its gas footprint.[258] Ideally, operators should continually endeavour to minimise the impacts on ground and surface water to reduce their shale gas footprint.[259] Some

[256] ECCO Foxvalley, Horizontal well and hydraulic fracturing, (accessed 17 June 2016) at http://ecco-foxvalley.net/blog/2013/01/15/fracking-what-is-it/

[257] Hydraulic Fracturing, Shale gas in Australia (accessed 12 May 2018) at < https://www.shale-gas.com.au/industry-operations/hydraulic-fracturing/> v

[258] Shale gas in Australia, Hydraulic fracturing, (accessed 18 June 2017) at http://www.shale-gas.com.au/industry-operations/hydraulic-fracturing/

[259] Ibid.

argue that the land-use footprint of shale and tight gas operations is not considerably more than for conventional operations.[260] Though given more wells are required to produce unconventional gas than are required to produce conventional gas, there are likely to be much larger production areas.[261] The DMIRS estimate that a well pad requires roughly 1.5 to 2 hectares of cleared land and an established gas field may contain a single well pad per 225 hectares.[262] After initial drilling has been completed the majority of land that operators use is rehabilitated, leaving only a small cleared area around each well head.[263] The Chamber of Minerals and Energy Western Australia suggest that a 'drilling rig, plus associated equipment and pits or vessels to store drilling fluids and waste will typically occupy and area of approximately 150 x 150 metres.'[264]

Shale and tight gas plays need a high concentration of wells and multistage hydraulic fracturing to ensure commercially viability, which leads to the use of high concentration of well pads to cut land costs, environmental impact and productivity through batch drilling.[265] The footprint of shale and tight gas operations is significantly reduced by the use of multi-well pads (MWP's).[266] MWP's also reduce production costs.[267] The size of a pad is affected by the amount of space required to accommodate equipment for horizontal drilling, hydraulic fracturing and for water storage.[268] A standard well site in the US averages between 1.5 and

[260] Natural Resources Canada, Environmental Considerations of Shale and Tight Resource Development, (accessed 12 May 2017) at https://www.nrcan.gc.ca/energy/sources/shale-tight-resources/17682>

[261] John Chandler, 'Shale gas and government agreements in WA' (2014) 33 *ARELJ*

[262] Department of Mines, Industry Regulation and Safety, Natural Gas from Shale and Tight Rocks, An overview of Western Australia's regulatory framework, February 2014, pg 6 at http://www.DMIRS.wa.gov.au/documents/Natural_Gas_from_Shale_and_Tight_Rocks_-_An_overview_of_Western_Australia_regulatory_framework.pdf

[263] Shale Gas in Australia, Hydraulic fracturing,(12 March 2017) at http://www.shale-gas.com.au/industry-operations/hydraulic-fracturing/

[264] Parliamentary Inquiry into the Implications for Western Australia fir Unconventional Gas, Submission for the Chamber of Minerals and Energy Western Australia, September 2013, pg 19 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/99D8D0023E339C6F48257C4000110456/$file/ev.fra.131004.sub.112.the+chamber+of+minerals+and+energy+of+western+australia.pdf>

[265] Ogoke, Victor, Bouchard, Genevieve, Inglehart, S.C., Simultaneous Operations in Multi-Well Pad: a Cost Effective way of Drilling Multi Wells Pad and Deliver 8 Fracs a Day, 2014, Society of Petroleum Engineers, 2014, SPE Annual Technical Conference and Exhibition, 27-29 October, Amsterdam, The Netherlands at https://www.onepetro.org/conference-paper/SPE-170744-MS

[266] Legislative Council of Western Australia, Standing Committee on Environment and Public Affairs, Report 42, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, pg 26 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf

[267] Id at 25.

[268] Id at 26.

2.0 hectares during drilling, though pads of over 2.0 hectares are possible.[269] The technological advances that have occurred in gas production over several decades has allowed operators to drill gas formations and redirect drills through gas-bearing areas enabling up to six wells to be operated from one surface drilling pad.[270] A number of horizontal wells can be drilled in multiple directions from a single well pad.[271] Generally, four wells are contained on a single pad, though pads have supported up to eight wells resulting in a smaller surface footprint, as less pads and roads are required to produce the same amount of gas as single well pads.[272]

The groundwater footprint of operations is the area required to sustain groundwater use and groundwater-dependent ecosystems.[273] The estimated groundwater footprint (to obtain water for fracking) in the Cooper Basin is 139 times the gas footprint.[274] An operator's footprint can be reduced by their investment in technology to lower the amount of water they use, however there are still concerns in relation to consumption levels, the management of competing water interests and the contamination of groundwater supplies.[275] Operators should be mindful of a locations groundwater sustainable yield which is defined as 'the groundwater extraction regime, measured over a specified planning timeframe that allows acceptable levels of stress and protects dependent economic, social, and environmental values.'[276]

Shale gas and tight gas operations result in a network of geographically dispersed 'production facilities and flow lines.'[277] The use of horizontal drilling and hydraulic fracturing has reduced

[269] Engineering Energy: Unconventional Gas Production, A study of shale gas is Australia, (Project 6, May 2013), pg 103 at < https://acola.org.au/wp/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf

[270] Shale Gas in Australia, Hydraulic fracturing, (accessed 12 April 2017) at http://www.shale-gas.com.au/industry-operations/hydraulic-fracturing/

[271] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Government Approach, 2015 Edition, pg 6 at http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/3913541ae03e783bf52cf5b948257ee5000a9d20/$file/3541.pdf

[272] Ibid

[273] Tom Gleeson, Yoshihide Wada, Marc F.P Bierkens & Ludovicus P.H van Beek, 'Water balance of global aquifers revealed by groundwater footprint' (2012) 488 *Nature* 197

[274] Ibid.

[275] Shale Gas, European Commission, Shale Gas, (accessed 12 September 2017) at https://ec.europa.eu/energy/en/topics/oil-gas-and-coal/shale-gas

[276] Department of Environment and Energy, Definition and approach to sustainable groundwater yield, (accessed 18 October 2016) at http://www.environment.gov.au/water/publications/environmental/groundwater/definition-and-approach-sustainable-groundwater-yield

[277] Guarnone M, Rossi F, Negri E, Grassi C, Genazzi D, and Zennaro R, "An Unconventional Mindset for Shale Gas Surface Facilities" (2012) 6 *Journal of National Gas Science and Engineering* 14

the overall surface footprint of operations allowing multiple wells (typically four wells are contained on a single pad though some have supported eight wells)[278] to be drilled from a single well pad.[279] In 2011, around 30 per cent of newly developed shale and tight gas wells in the United States and Canada were multiple wells drilled from a single pad.[280] Technological advances now allow for 12 -16 wells to be drilled from a single well pad.[281]

Shale and tight gas reserves cover large areas in geological formations.[282] These formations play a significant part in the exploration and production of shale and tight gas and have an impact on licensing regimes.[283] For example, in Western Australia a production licence is limited to, and corresponds with the 'size of discovery'.[284] An exploration permit is limited to 400 blocks (32,000 square kilometres).[285] These limitations suit conventional reservoirs where licences are around 320 square kilometres.[286] In South Australia an exploration licence cannot be more than 10,000 square kilometres.[287] A production licence cannot exceed twice the area under which the discovery is more likely than not to exceed,[288] or 100 square kilometres.[289]

The question of whether shale and tight gas operations are best identified as a set of operations undertaken within the boundaries of a single tenement or single well or classified by their geological formation over a sequence or series of tenements is not examined in this thesis. It is worth noting that in Colorado, geographic area plans take account of the activities of a

[278] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Government Approach, 2015 Edition, pg 11 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf

[279] Department of Mines, Industry Regulation and Safety, Natural Gas from Shale and Tight Rocks, An overview of Western Australia's regulatory framework, February 2014, page 6 at http://www.DMIRS.wa.gov.au/documents/Natural_Gas_from_Shale_and_Tight_Rocks_-_An_overview_of_Western_Australia_regulatory_framework.pdf

[280] International Energy Agency, Golden Rules for a Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, 2011, pg 47 at http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf

[281] Brian K. Bohm, P.G, J. Daniel Arthur, P.E, Horizontal drilling and hydraulic fracturing considerations for shale gas wells, ALL Consulting, 13-14October 2010

[282] Utah Geological Survey, What is a Formation? (accessed 19 June 2017) at https://geology.utah.gov

[283] John Chandler, 'Shale gas and government agreements in WA' (2014) 33 *ARELJ*

[284] Id at 48.

[285] *Petroleum and Geothermal Energy Resources Act* 1967, s 31(1)

[286] John Chandler, How Are Onshore Licensing Regimes in Australia dealing with the challenges of Petroleum in Shale and other Tight Rocks? Australian Resources and Energy Law Journal, Vol. 34, No. 3, 2015, p. 251-266

[287] *Petroleum and Geothermal Energy Act 2000*, s 24(2)

[288] *Petroleum and Geothermal Energy Act* 2000, s 37(1)(a)

[289] *Petroleum and Geothermal Energy Act* 2000, s 37(1)(b)

number of operators in entire gas fields or basins to enable the implementation of basin specific rules that promote the purposes of the OGCA.[290]

2.2.3 Resource classifications and prospectivity

The four main resource classification types are production, reserves, contingent resources and prospective resources.[291] The production classification refers to the amount of gas recovered at a given date, the reserves classification to the part of resource that is commercially recoverable and confirmed for development, the contingent resources classification is less reliable and is potentially recoverable but not ready for commercial development and prospective resources.[292] Prospective resources are undiscovered accumulations[293] and considered 'potentially recoverable' on the basis of secondary evidence as these deposits are yet to be drilled.[294] For prospective resources to become contingent resources the barriers that block commercial development must be removed.[295] Contingent and prospective resources are less certain than production and reserves given there are often commercial and/or technical barriers that need to be addressed before operators have confidence in production volumes.[296]

Technically recoverable resources are 'the volumes of oil and natural gas that could be produced with current technology, regardless of oil and natural gas prices and production costs.'[297] Economically recoverable resources are those that could be commercially produced under market conditions. The amount of gas in a formation prior to production is the 'original gas in-place.'[298]

[290] COGCC Rule 513
[291] Kane Rawsthorn, Shale Gas Prospectivity Potential, AWT International, Prepared for: Australian Council of Learned Academies, 23 January 2013 at https://acola.org.au/wp/PDF/SAF06Consultants/AWTShale%20Gas%20Prospectivity%20Potential%20Jan2013.pdf
[292] Ibid.
[293] SPE International, SPE Petroleum Resources Management System Guide for Non-Technical Users (accessed 24 June 2017), page 3 at http://www.spe.org/industry/docs/PRMS_guide_non_tech.pdf
[294] Ibid.
[295] Ibid.
[296] Above, note 280.
[297] United States Energy Information Administration, Technically Recoverable Shale Oil and Shale Gas Resources: China, September 2015, pg 3 at https://www.eia.gov/analysis/studies/worldshalegas/pdf/China_2013.pdf
[298] I.O. Obielum, P.U. Giegbefumwen, P.O. Ogbeide, A P/Z Plot for Estimating Original Gas in Place in a Geo-pressured Gas Reservoir by the Use of a Modified Material Balance Equation, SPE Nigeria Annual

Operators try to locate prospective areas and align their wells for maximum borehole exposure.[299] Shale gas is located in 'plays', which are shale formations that contain deposits with similar geologic and geographic properties.[300] A play that meets certain benchmarks is classified as a shale gas 'sweet spot'.[301]

2.2.4 Reserves and basins

According to the United States Energy Information Administration there are approximately 7299 trillion cubic feet (tcf) of technically recoverable shale gas resources distributed amongst 137 formations in 41 countries.[302] The focus on conventional gas exploitation in the United States has resulted in a significant decline in reserves.[303] In fact, conventional gas production dropped 39 percent between 1990 and 2009.[304]

The United States reportedly holds 610 tcf of technically recoverable shale natural gas resources and ranks fourth in the world for shale gas resources.[305] To put this into some context, the Canning Basin alone reportedly contains 235 tcf[306] of technically recoverable shale natural gas. This is roughly double the amount of gas held in Western Australia's offshore

International Conference, Society of Petroleum Engineers, 2015 < https://www.onepetro.org/conference-paper/SPE-178354-MS>

[299] Kane Rawsthorn, Shale Gas Prospectivity Potential, AWT International, Prepared for: Australian Council of Learned Academies, 23 January 2013 at https://acola.org.au/wp/PDF/SAF06Consultants/AWTShale%20Gas%20Prospectivity%20Potential%20Jan2013.pdf

[300] Energy Information Administration, What is a Shale "Play"?, (accessed 17 May 2017) at http://geology.com/energy/shale-gas/

[301] Above, note 287.

[302] US Energy Information Administration, Analysis & Projections-Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States, 13 June 2013, at < http://www.eia.gov/analysis/studies/worldshalegas/>

[303] Alberta Energy Regulator, What is Unconventional Oil and Gas? , (accessed 15 June 2017) at https://www.aer.ca/about-aer/spotlight-on/unconventional-regulatory-framework/what-is-unconventional-oil-and-gas

[304] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 6 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF

[305] US Energy Information Administration, Shale in the United States, 2016 at https://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm

[306] US Energy Information Administration, World Shale Resource Assessments, 2015 at http://www.eia.gov/analysis/studies/worldshalegas/

conventional fields.[307] It is estimated that 1 tcf of natural gas would satisfy Australia's yearly domestic gas usage[308] or a city the size of Perth for 10 years.[309] According to the Australian Energy Market Operator, supplying gas to the domestic market in Western Australia is dependent on sustained development of gas reserves, though reserves associated with domestic gas production exhibit a natural decline.[310] This is of particular significance to Western Australia which consumes more gas domestically than any other state in Australia.[311]

Shale gas accounted for 2 per cent of United States domestic gas resources in the 2001 and 47 per cent in 2013.[312] Approximately 12.3 tcf of dry natural gas was produced directly from shale and tight oil resources in the United States in 2014.[313] Production in this area grew by an average of 48 per cent from 2006 to 2010.[314] It is projected that shale gas will account for almost half of total natural gas production in 2035.[315] Shale gas and tight oil is projected to grow from roughly 14 tcf in 2015 to 29 tcf in 2040.[316]

Shale and tight gas delivers the United States over 2 tcf annually to the domestic market and it is anticipated that it will overtake coal seam gas production by 2025 with enhancements in exploration, production, gas price increases and developing plays.[317] Australia's shale and tight gas reserves are difficult to accurately verify given many of its basins are largely unexplored and underexplored.[318] Geoscience Australia maintain that 'Australia has

[307] CSIRO, Australia's shale gas potential, (accessed 17 June 2017) at http://www.csiro.au/Outcomes/Energy/Energy-from-oil-and-gas/Shale-gas-potential.aspx
[308] CSIRO, Australia's shale gas resources, (accessed 17 June 2017) at http://www.csiro.au/Outcomes/Energy/Energy-from-oil-and-gas/Shale-gas-potential.aspx
[309] APPEA, Report to the CoAG Energy Council Unconventional Gas in Australia, July 2016, pg 41 at http://www.appea.com.au/wp-content/uploads/2016/08/APPEA-Report-to-CoAG-2016-Unconventional-Gas-in-Australia.pdf
[310] Australian Energy Market Operator, Gas statement of Opportunities for Western Australia, December 2017, 2018, pg 23
[311] AEMO, *Gas Statement of Opportunities for Western Australia,* 2017 at https://www.aemo.com.au/Media-Centre/2017-WA-Gas-Statement-of-Opportunities
[312]US Energy Information Administration, *Annual Energy Outlook 2015* at <http://www.eia.gov/forecasts/aeo>
[313] United States Energy Information Administration, How much shale gas is produced in the United States?, (accessed 17 June 2017) at http://www.eia.gov/tools/faqs/faq.cfm?id=907&t=8
[314] US Energy Information Administration, Annual Energy Outlook 2011: With Projections to 2035, 4, 2011.
[315] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 6 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF
[316] Above, note 301.
[317] Department of State Development, Resource Plays, Shale gas, (16 April 2017) at http://petroleum.statedevelopment.sa.gov.au/prospectivity/resource_plays#gas
[318] Kane Rawsthorn, Shale Gas Prospectivity Potential, AWT International, Prepared for: Australian Council of Learned Academies, 23 January 2013, pg 12 at

significant shale gas resources, but such resources are poorly understood and quantified, and any estimates of potential resources have a high degree of uncertainty…Understanding of the potential tight gas and shale gas resource in Australia is limited.'[319]

Australia's shale and tight gas reserves are twice the size of those estimated for coal seam gas.[320] It is difficult to do more that estimate the size and extent of reserves given that the final volumes cannot be identified pre-production.[321] Resource estimates fluctuate as new extraction technologies emerge, as markets develop, and once operators begin to produce.[322]

The United States Energy Information Administration assessed shale formations in 41 countries outside of the United States in 2013.[323] In Australia, the Canning, Cooper, Maryborough, Perth, Georgina, and Beetaloo basins were ranked according to composite play success and prospective area success. These basins reportedly hold 2,046 tcf of risked shale gas in-place[324] with 437 tcf technically recoverable.[325] This ranks Australia seventh out of the 41 countries reviewed for shale gas resources.[326] Western Australia reportedly holds the fifth largest reserves of shale gas in the world, with a total of 280 tcf.[327] The Canning Basin contains 235 tcf of technically recoverable gas.[328]

https://acola.org.au/wp/PDF/SAF06Consultants/AWTShale%20Gas%20Prospectivity%20Potential%20Jan2013.pdf

[319] Geoscience Australia, Gas, Summary, (accessed 12 May 2017) at www.ga.gov.au/aera/gas

[320] Frogtech Pty Ltd, Potential Geological Risks Associated with Shale Gas Production in Australia, Melbourne: Australian Council of Learned Academics, 2013, pg 2 at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf

[321] US Energy Information Administration, Technically Recoverable Shale Oil and Shale Gas Resources: China, September 2015, pg 3 at https://www.eia.gov/analysis/studies/worldshalegas/pdf/China_2013.pdf

[322] Ibid.

[323] US Energy Information Administration, Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States, 2013 at http://www.eia.gov/analysis/studies/worldshalegas/

[324] 'The technically recoverable resource estimate for shale gas in the report is established by multiplying the risked gas in-place by a shale gas recovery factor, which incorporates a number of geological inputs and analogs that are appropriate to each shale gas basin and formation. The risked gas in-place estimate is derived by first estimating the amount of 'gas in-place' resource for a prospective area within the basin, and then de-rating that gas in-place by factors that account for the current level of knowledge of the resource and the capability of the technology to eventually tap into the resource' at http://www.greencarcongress.com/2011/04/eia-20110406.html

[325] Norton Rose Fulbright, Shale gas handbook, A quick-reference guide for companies involved in the exploitation of unconventional gas resources, June 2015, pg 23 at http://www.nortonrosefulbright.com/files/norton-rose-fulbright-shale-gas-handbook-108992.pdf ,

[326] Ibid.

[327] Department of Mines and Petroleum, Natural Gas from Tight Rocks (accessed 17 June 2017) at http://www.dmp.wa.gov.au/Petroleum/Natural-gas-from-shale-and-tight-1591.aspx

[328] Ibid.

The following map shows the location of Australia's shale and tight gas sedimentary basins:

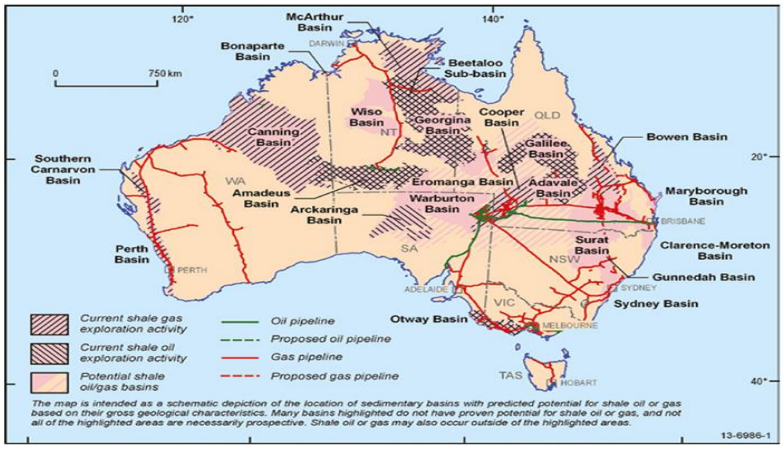

Figure 5 Size and extent of Australia's basins[329]

The Canning Basin which is located 1500 kilometres northeast of Perth (in Western Australia), has an onshore area of about 530 000 square kilometres.[330] The basin has several organic-rich shales, including the Laurel and Lower Anderson shales and the large Goldwyer shale.[331] The basin holds 1,227 tcf risked shale gas and shale oil resources in place of which 225 tcf is technically recoverable.[332] It is estimated that there is an additional 38 tcf of recoverable shale gas in the Laurel formation.[333]

[329] Commonwealth of Australia (Geoscience Australia) 2013. This product is released under the Creative Commons Attribution 3.0 Australia Licence

[330] Department of Mines and Petroleum, Summary of Petroleum Prospectivity: Canning Basin, at http://www.DMIRS.wa.gov.au/documents/AREA_SUMMARY_CANNING.pdf

[331] United States Energy Information Administration, Independent Statistics & Analysis, Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formation in 41 Countries Outside the United States, III-28 at < https://www.eia.gov/analysis/studies/worldshalegas/pdf/overview.pdf>

[332] Id at III-16.

[333] Cook, P, Beck, V, Brereton, D, Clark, R, Fisher, B, Kentish, S, Toomey, J and Williams, J (2013). Securing Australia's Future – Engineering energy: unconventional gas production,pg 29 at http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-6

The Cooper Basin in north-east South Australia and south-west Queensland[334] covers around 121 382 square kilometres.[335] The basin contains three major troughs in the Roseneath Epsilon Murteree (REM). The REM contains 325 tcf of risked gas in place.[336] The REM has three formations; the Nappamerri, Patchawarra and Tenappera[337] which holds 93 tcf of technically recoverable shale gas.[338] The 93 tcf cubic feet comprises 89 tcf in the Nappamerri; 4 tcf recoverable in the Pathawarra and 0 recoverable in the Tenappera.[339]

The REM is likely to be Australia's most easily developed basin[340] and its only shale gas sweet spot.[341] The REM is suitably mature for hydrocarbon generation, 'with laterally extensive thick intervals and a lithotype that is organic-rich (usually more than 2% organic matter) with a low clay content.'[342] The REM is a recognised natural gas region given it has existing infrastructure.[343] There are over 5000 kilometres of pipelines connecting the Cooper Basin to gas markets in eastern and southern state capitals and to a liquid load out facility at Port Bonython.[344] Given there is currently uninterrupted pipeline access to gas markets in New South Wales, Queensland and South Australia, and there is obvious potential for domestic or export use.[345]

[334] Santos, Cooper Basin (overview) (accessed 15 June 2017) at http://www.santos.com/our-activities/eastern-australia/cooper-basin-overview-.aspx
[335] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013 at <http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf>
[336] Id at Attachment C-1.
[337] United States Energy Information Administration, Independent Statistics & Analysis, Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formation in 41 Countries Outside the United States, III-28 at < https://www.eia.gov/analysis/studies/worldshalegas/pdf/overview.pdf>
[338] Ibid
[339] Above, note 325 at Attachment C-1.
[340] Ibid .
[341] Energy Quest, Encouraging signs for Australian shale gas, 16 July 2011 at http://www.energyquest.com.au/insightsandanalysis.php?id=103
[342] Kane Rawsthorn, Shale Gas Prospectivity Potential, AWT International, Prepared for: Australian Council of Learned Academies, 23 January 2013, pg 12 at https://acola.org.au/wp/PDF/SAF06Consultants/AWTShale%20Gas%20Prospectivity%20Potential%20Jan2013.pdf
[343] Santos, Moomba 191 and Beyond, 28 August 2013 at http://www.santos.com/library/130828_Moomba_191_and_beyond.pdf
[344] Department of State Development, Roadmap for Unconventional gas projects in SA, 2012 , pg 178 at http://www.petroleum.dmitre.sa.gov.au/__data/assets/pdf_file/0008/179621/Roadmap_Unconventional_Gas_Projects_SA_12-12-12_web.pdf
[345] Kane Rawsthorn, Shale Gas Prospectivity Potential, AWT International, Prepared for: Australian Council of Learned Academies, 23 January 2013, pg 14 at https://acola.org.au/wp/PDF/SAF06Consultants/AWTShale%20Gas%20Prospectivity%20Potential%20Jan2013.pdf

The Maryborough Basin is located about 250 kilometres north of Brisbane and covers an onshore area of 11136.95 square kilometres.[346] It has two potential shale gas targets within the cretaceous Maryborough formation[347] that are highly unexplored. The Perth Basin is almost 100 000 square kilometres, most of which lies offshore. The onshore part covers about 45 000 square kilometres.[348] The Basin contains two main organic-rich shale formations, the Permian Carynginia and the Triassic Kockatea.[349] The Carynginia formation holds 124 tcf risked and 25 tcf recoverable and the Kockatea holds 44 tcf and 8 tcf recoverable.[350] The basin contains 33 tcf recoverable (shale gas) in Kockatea, Carynginia and Irwin Formations and 12 tcf (tight gas) in the High Cliff, Dongara and Wagina Sandstones.[351]

The Georgina Basin is 323 749 square kilometres[352] and is a largely unexplored basin located in Northern Australia. The basin overlaps the Northern Territory and Queensland border.[353] The L. Arthur shale (Dulcie Trough) holds 41 tcf risked and 8 tcf recoverable whilst the L. Arthur shale (Toko Trough) holds 27 tcf risked and 5 tcf recoverable. [354]

The Beetaloo Basin is a 36 260 square kilometre rift basin located in the Northern Territory, approximately 640 kilometres southeast of Darwin. The basin outline is defined by the Walton High to the north, the Helen Springs High in the south, and the Batten Trough in the east. Its western margin is projected to extend to the Daly Waters Arch.[355] The M. Velkerri shale holds

[346] United States Energy Information Administration, Independent Statistics & Analysis, Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formation in 41 Countries Outside the United States, III-28 at < https://www.eia.gov/analysis/studies/worldshalegas/pdf/overview.pdf>
[347] Ibid.
[348] Department of Mines and Petroleum, Western Australia's Petroleum and Geothermal Explorer's Guide – 2014 Edition, pg 54 at < http://www.dmp.wa.gov.au/Documents/Petroleum/PD-RES-PUB-100D.pdf>
[349] United States Energy Information Administration, Independent Statistics & Analysis, Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formation in 41 Countries Outside the United States, III-20 at < https://www.eia.gov/analysis/studies/worldshalegas/pdf/overview.pdf
[350] Id at Attachment C-1.
[351] Department of Mines and Petroleum, Submission to the Legislative Council Standing Committee on Environment and Public Affairs: 'Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas', 2013, pg 8, at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf
[352] United States Energy Information Administration, Analysis and Projections, World Shale Resource Assessments, 2015 at http://www.eia.gov/analysis/studies/worldshalegas/
[353] Ibid.
[354] Id at Attachment C-1.
[355] Id at III-40.

94 tcf risked and 22 tcf recoverable whilst the L. Kyalla shale holds 100 tcf risked and 22 tcf recoverable.[356]

Colorado's Potential Gas Committee recently assessed the United States' natural gas resources determining that it held a total technically recoverable resource of 2,515 tcf.[357] The assessment of 2,515 tcf includes 2357 tcf of gas potentially recoverable from "traditional" reservoirs (conventional, tight sands and carbonates, and shales).[358] The 9.6-tcf (2.3%) net increase for the Rocky Mountain area resulted from the re-examination of new data and drilling results from the Cretaceous Niobrara shale play in western Colorado's Piceance basin and the Niobrara fractured-carbonate play in the Denver basin.

The Wattenberg Gas Field (WGF) in the Denver-Julesburg Basin in northeast Colorado covers roughly 81 townships (1.9 million acres).[359] In 2006, the WGF was the seventh largest gas field in the United States and the largest gas producing field in Colorado.[360] Current production is ≈1.2 billion cubic ft (equivalent) per day (Bcfe/d) from over 13,000 producing wells and cumulative production to date is ≈4.2 tcf (equivalent). Along with the WGF, Colorado contains the Hilliard-Baxter-Mancos, the Lewis shale, the Mancos shale and the Piceance basin.

The Hilliard-Baxter-Mancos is roughly 42 517 square kilometres and has an average expected ultimate recovery (EUR) of 0.18 billion cubic feet per well and approximately 3.77 tcf of technically recoverable gas.[361] The Lewis is roughly 19 440 square kilometres and has an average estimate ultimate recovery of 1.3 billion cubic feet per well and roughly 11.6 tcf feet of technically recoverable gas.[362] The Mancos has been assessed as being roughly 17 065 square kilometres and (excluding the Masaverde, Wasatch and other formations in the Uinta

[356] Id at Attachment C-1.
[357] Potential Gas Committee, Potential Gas Committee reports increase in magnitude of United States Natural Gas Resource Base, (accessed 7 May 2017) at http://potentialgas.org/press-release
[358] Ibid.
[359] Wattenberg Gas Field, USA Region, South Rockies Business Unit DJ Basin Team. Encana – energy for people,(accessed 19 June 2016) at https://www.erieco.gov/DocumentCenter/Home/View/384
[360] Ibid.
[361] United States Energy Information Administration, Review of Emerging Resources: United States Shale Gas and Shale Oil Plays, July 2011, at http://www.ourenergypolicy.org/wp-content/uploads/2013/02/usshaleplays-1.pdf
[362] United States Energy Information Administration, Review of Emerging Resources: United States Shale Gas and Shale Oil Plays, July 2011, at http://www.ourenergypolicy.org/wp-content/uploads/2013/02/usshaleplays-1.pdf

basin) and when assessed in 2011 had a EUR of roughly 1.0 billion cubic feet per well and was estimated to have 21.02 tcf of technically recoverable gas.[363] The United States Geological Survey determined *that the Mancos Shale in Piceance Basin contained an estimated mean of of 66 tcf of shale natural gas*.[364] The Piceance basin is roughly 17 065 square kilometres and contains between 1.8 tcf and 4.9 tcf. The mean estimated resource is 3.1 tcf of natural gas.[365]

Western Australia, South Australia and Colorado all have large shale and tight deposits. As pointed out by Dr Nina Triche, significant resource estimates can create unrealistic commercial viability expectations.[366]

2.2.5 Water volume, its role and availability

2.2.5.1 Volume

The demand for water to carry out hydraulic fracturing is placing pressure on water sources in some regions.[367] As well as being used to carry out hydraulic fracturing, water is used during drilling to cool drill bits and to assist in transferring drill cuttings to the surface.[368] The DMIRS estimate that a vertical well with three fracture stages averages seven million litres of water per well, comprising one million litres for drilling and six million litres for hydraulic fracturing.[369] A horizontal well (with a horizontal length of 1 km) with ten fracture stages averages 21 million litres of water per well; one million litres for drilling and 20 million litres for hydraulic fracture stimulation.[370] In the United States a single well stage fracture requires roughly 2000 kilolitres

[363] Ibid.
[364] USGS, USGS Estimates 66 Trillion Cubic Feet of Natural Gas in Colorado's Mancos Shale Formation, (accessed 12 May 2017) at https://www.usgs.gov/news/usgs-estimates-66-trillion-cubic-feet-natural-gas-colorado-s-mancos-shale-formation
[365] Above, note 350.
[366] Dr Nina Triche, Unconventional Resources: Applying the World To (Western Australia), Water Management for Shale and Tight Gas Resources, June 8-9, 2015 – Perth, Western Australia
[367] Pam Boschee, Produced and Flowback Water Recycling and Reuse, 2014 at <http://www.halliburton.com/public/multichem/contents/Papers_and_Articles/web/Feb-2014-Oil-Gas-Facilities-Article.pdf>
[368] Colorado Oil and Gas Association, Water use fast facts, (accessed 12 February 2017) at www.coga.org
[369] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Government Approach, 2015 Edition, pg 28 at http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/3913541ae03e783bf52cf5b948257ee5000a9d20/$file/3541.pdf
[370] Ibid.

(1000 litres = 1 kilolitre (kl) of water).[371] In Colorado, a standard well requires around five million gallons of water to drill and fracture, depending on the basin and geological formation.[372]

The volume of water needed to exploit shale and tight gas in dry areas where there is increasing competition for limited water supplies will likely lead to a shortage of water (and increased cost) for irrigation, livestock watering, residential use.[373] A substantial amount of water is required to produce shale and tight gas in commercial quantities and it varies significantly from project to project and is often determined by the size and length of a well and the type of rocks being fractured. It is estimated that an average of 20 mega litres of water is used per horizontal well, filling about eight average Olympic sized swimming pools.[374] In the United States the median volume of water exploited per shale gas well in the Barnett shale is 10 600 kilolitres, in the Haynesville shale 21 500 kl's , in the Eagleford shale 16 500 kl's and in the Marcellus shale 17 100 kl's.[375] The United Nations estimate that a single horizontal well will use between 11 and 34 million litres of water.[376] In the United States operators report recycling capacity of up to 1.5 million barrels of water per day and have recycled up to 50 million barrels of water since 2012.[377]

[371] Department of Mines, Industry Regulation and Safety, Hydraulic fracture stimulation – water use and management, (accessed 19 September 2017) at http://dmp.wa.gov.au/Petroleum/Hydraulic-fracture-stimulation-20057.aspx

[372] Accenture, Water and Shale Gas Development, Leveraging the US experience in new shale developments, (accessed 14 June 2017) at http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Water-And-Shale-Gas-Development.pdf

[373] National Energy Technology Laboratory, Modern Shale Gas Development in the United States: An Update, U.S Department of Energy, September 2013

[374] Gas Industry Social & Environmental Research Alliance, (accessed 10 June 2017) at http://www.gisera.org.au/

[375] P Cook, V Beck, D Brereton, R Clark, B Fisher, S Kentish, J Toomey and J Williams, Engineering Energy: Unconventional Gas Production, Report for the Australian Council of Learned Academies, May 2013, p 35 at <https://acola.org.au/wp/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf>

[376] UNEP Global Environmental Alert Service, Gas Fracking: Can we safely squeeze the rocks?, (accessed 12 March 2017) at http://na.unep.net/geas/archive/pdfs/GEAS_Nov2012_Fracking.pdf

[377] Water Conservation and Recycling Symposium, (accessed 18 March 2017) at http://www.rrc.state.tx.us/about-us/commissioners/craddick/water-recycling-symposium/

According to DMIRS, an 18 hole golf course requires between 360 000 and 550 000 kl's of water per annum.[378] Other activities that require the same amount of water as a 10 stage fracture well include:

> '1,100 head of cattle or 11,000 head of sheep for a year; irrigating just under 1 hectare of lucerne, or a 1 hectare commercial sized market garden for one year; 8 Olympic sized swimming pools; the amount of water used by 45 domestic garden bores in the Perth metro area, maintaining Domain Stadium'[379]

2.2.5.2 The role of water

The water that operators need to exploit shale and tight gas will be surface water from streams, ponds or lakes; groundwater from aquifers or water from alternative sources i.e., drainage water, recycled water or water trucked in from offsite. The risks and challenges in securing this water during dry periods will likely see operators competing directly with agricultural and domestic water users. It is highly likely that shale and tight gas exploitation will adversely impact water resources beyond production zones and production periods and, given groundwater is becoming an increasingly important water supply source worldwide, understanding the amount of groundwater used versus the volume available is vital in order to evaluate future water availability.

There are a myriad of issues that require management, including but not limited to, the volume of water used for hydraulic fracturing; the protection of potable aquifers and the handling of produced water.[380] In general operators use more water for horizontal wells compared to vertical wells given they require more fracture stages and additional stages of hydraulic fracture stimulation result in the need for greater volumes of water and longer and more complex fracture patterns require more water. The larger the number of naturally occurring fractures in the rock formation, the less hydraulic fracture stimulation is required. An operator may decide

[378] Department of Mines, Industry Regulation and Safety, Hydraulic fracture stimulation – water use and management, (accessed 17 June 2016) at http://dmp.wa.gov.au/Petroleum/Hydraulic-fracture-stimulation-20057.aspx
[379] Ibid.
[380] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013, pg 4 at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf

to re-fracture an existing well during its production life which requires water for hydraulic fracture stimulation activities.

Water is also needed for accommodation, dust suppression, construction and related activities.[381] The significant amount of water required almost certainly leads to issues of competition[382], i.e., competition between operators, farmers and domestic water users.[383] The demand for freshwater, the production of wastewater and groundwater contamination are all areas of concern.[384] Concern is likely to be greatest when there are competing demands from water users (for example from urban and agricultural development) and declining water in aquifers.[385]

2.2.5.3 Water availability

The bulk of Australia's shale and tight gas reserves are located in areas of medium to high drought severity and medium to high seasonal variability in water supplies.[386] The arid conditions in the Canning Basin and Cooper Basin will likely result in significant regulatory challenges.[387] The health of the world's aquifers was considered with the release of satellite data by the National Aeronautics and Space Administration (NASA).[388] The data showed that the Canning basin has the third-highest rate of depletion in the world with the Great Artesian Basin (GAB) amongst the healthiest.[389] The authors of the study contend that mining activities in the rural Canning Basin are possibly influencing the GRACE signal.[390]

[381] Department of Mines and Petroleum, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Governmenr Approach, 2015 Edition, pg 28
[382] National Water Commission, Canberra, Water for mining and unconventional gas under the National Water Initiative, 2014, pg 1
[383] Paul Reig, Tianyi Luo, and Jonathan N. Proctor, World Resources Institute, Global Shale Gas Development, Water Availability and Business Risks, (2014) at 50 at http://www.wri.org/sites/default/files/wri14_report_shalegas.pdf
[384] Shale Gas Information Platform, What are the risks?, (accessed 10 May 2017) at http://www.shale-gas-information-platform.org/what-are-the-risks.html
[385] Rahm, B, G and Riha, S, J, 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci: Processes Impacts* 1400, 1401 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H
[386] Paul Reig, Tianyi Luo and Jonathan N. Proctor, 'Global Shale Gas Development – Water Availability and Business Risks', World Resources Institute, 2014, 50
[387] Ibid.
[388] Richey, A. S., B. F. Thomas, M.-H. Lo, J. T. Reager, J. S. Famiglietti, K. Voss, S. Swenson, and M. Rodell, 'Quantifying renewable groundwater stress with GRACE' (2015) *Water Resources. Res*. 51
[389] Ibid.
[390] Id at 5228.

Groundwater is becoming an increasingly important water supply source worldwide and understanding the amount of groundwater used versus the volume available is vital in order to evaluate future water availability.[391]

The use of groundwater for hydraulic fracturing will have an effect on the environment and other water users.[392] It is likely that the risk in securing water for production during dry periods will lead to increased operational and reputational risks for operators who will have to compete for scarce resources with both agricultural and domestic water users.[393] It is also likely that shale and tight gas production will negatively impact water resources beyond production zones and production periods given significant amounts of water are used to facilitate exploitation.[394]

Some industry commentators argue that operators in Western Australia and South Australia will need to rely on slowly recharged groundwater.[395] Those operating in the Canning Basin and Cooper Basin will be key consumers of groundwater relative to sustainable extraction levels.[396] Groundwater is becoming an increasingly important water supply source worldwide and understanding the amount of groundwater used versus the volume available is vital in order to evaluate future water availability.[397]

The GAB is one of the largest underground water reservoirs in the world and covers approximately 22 percent of Australia.[398] The GAB covers most of Queensland, the Northern Territory, New South Wales and parts of South Australia to depths of up to 3000 metres and

[391] Id at 51.
[392] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013, pg 4, at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf
[393] Paul Reig, Tianyi Luo and Jonathan N. Proctor, 'Global Shale Gas Development – Water Availability and Business Risks', World Resources Institute, 2014, 50
[394] IHS Cambridge Energy Research Associates in their report *Fuelling North America's Energy Future – The Unconventional Natural Gas Revolution and the Carbon Agenda,* (2010) at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/43227/1296-ihs-cera-special-report.pdf
[395] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013, pg 4, at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf
[396] Ibid.
[397] Richey, A. S., B. F. Thomas, M.-H. Lo, J. T. Reager, J. S. Famiglietti, K. Voss, S. Swenson, and M. Rodell 'Quantifying renewable groundwater stress with GRACE' (2015) *Water Resources. Res*. 51,
[398] Department of Environment, Great Artesian Basin, (accessed 12 October 2017) at http://www.environment.gov.au/water/environment/great-artesian-basin

is approximately 1.7 million square kilometres and stores around 65 000 gigalitres of water.[399] The GAB contains various geological basins ranging in age from 200 years to 65 million years which sit above deeper, older geological basins that have newer surface drainage divisions such as Lake Eyre and Murray-Darling river basins situated on top of them.[400] There are six major aquifers in the GAB that have an average thickness of 150-200 metres and are mostly sandstones recharged by rainfall with stream flows penetrating the exposed sandstones on the eastern edge of the basin. The deepest aquifer, the Hutton Sandstone, extends to a depth of approximately 3000 metres in the Cooper Basin region.

The Cooper Basin is covered by the Hutton Sandstone aquifer which has shale layers beneath it that are close to freshwater aquifers.[401] The division between the GAB and the highly prospective gas is inconsistent and ranges from 300-800 metres.[402] The GAB is separated from gas by a number of low permeability beds the most significant of which is the Triassic Nappamerri Group ('Nappamerri').[403] This bed is up to 500 metres thick. The Nappamerri is mainly siltstone; though it does contain areas that have higher permeability sandstone beds which have the potential to act as pathways between the Cooper Basin and the GAB.[404]

The Canning Superbasin is Australia's second largest aquifer.[405] The Canning Super Basin is restocked by rainwater ensuring there is water available all year round.[406] The aquifer provides water for pastoral use, drinking water and industry throughout the Kimberley. The aquifer

[399] Cook, P, Beck, V, Brereton, D, Clark, R, Fisher, B, Kentish, S, Toomey, J and Williams, J (2013). Securing Australia's Future – Engineering energy: unconventional gas production,pg 124 at http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-6

[400] Smerdon, B. D., Marston, F. M., & Ransley, T. R. (Water resource assessment for the Great Artesian Basin. Australia: Synthesis of a report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment. (CSIRO Water for a Healthy Country Flagship, Australia, 2012).

[401] Stephanie Neitzel, P.E. Esq. Principal WaterRich Advisors LLC, Centennial, Colorado, Water quality regulations for unconventional gas production, United States and Australia comparison, (accessed 14 June 2017) pg 7 at http://www.awa.asn.au/documents/136%20SNeitzel.pdf

[402] Gravestock, D.I., Hibburt, J.E. and Drexel, J.F. (eds), *The petroleum geology of the SA. Volume 4: Cooper Basin* Report Book 98/9(Primary Industries and Resources SA (PIRSA), 1st Edition, November 1998) at http://www.petroleum.statedevelopment.sa.gov.au/home/access_to_data/petroleum_publications/petroleum_geology_of_south_australia/vol_4_-_cooper_basin_downsampled

[403] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013, pg 10 at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf

[404] Above, note 390.

[405] Buru Energy, Hydraulic Fracturing, (accessed 27 July 2016) at http://www.buruenergy.com/canning-basin/hydraulic-fracturing-2/

[406] Ibid.

recharge from annual rainfall is 827 000 mega litres a year whilst domestic water supply for Broome is approximately 5400 mega litres a year.[407]

The Canning Super Basin is unique, in that less than 1 percent of the aquifer is covered by residential areas, though it has the third highest rate of GRACE-derived depletion (-9.40 ± 1.34 mm/yr).[408] It has been suggested that mining activities in the rural Canning Basin are likely influencing the GRACE signal which is lost in the statistics-based use rate of -0.002 mm/yr.[409] The renewable groundwater stress ratio, quantified according to a ratio of groundwater use to availability, in the Canning Super Basin is -1.6, which implies that about 150 percent more water is depleted than is naturally available and water in storage is used to supplement available supplies. In reality, storage loss and environmental degradation can occur when the renewable groundwater stress is less than one.[410]

Some industry commentators suggest that, if extensive gas extraction occurs in the Canning Super Basin, alternatives to fresh water; such as saline water, reuse/recycling and non-water based fracking fluids will need to be considered.[411] In contrast, Buru stated that in 2014, it was licenced to take up to 50 mega litres per annum of water at each of its well sites as part of its tight gas pilot program.[412] Buru estimated that 31 mega litres of water was required for hydraulic fracturing which represented less than 0.005 percent of the annual sustainable yield of the basin or less than two days water use for the town of Broome.[413] According to Buru, if the aquifer annual recharge from rainfall was equal to a 205 litre drum, then the forecast annual water use of 31 mega litres would equate to less than a teaspoon, compared to the West Kimberley region's household water use which equates to a 10 litre bucket.[414] Buru estimated that the maximum total water usage for the four wells in the program is less than eight days'

[407] Buru Energy, Buru Energy's proposed gas developments in the Canning Basin – Questions and Answers, March 2014, pg 13 at http://www.buruenergy.com/wp-content/uploads/Proposed-Gas-Developments-QA1.pdf
[408] Richey, A. S., B. F. Thomas, M.-H. Lo, J. T. Reager, J. S. Famiglietti, K. Voss, S. Swenson, and M. Rodell, 'Quantifying renewable groundwater stress with GRACE' (2015) *Water Resources. Res.* 51
[409] Ibid.
[410] Ibid.
[411] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013 at <http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf, pg 17>
[412] Buru Energy, Hydraulic Fracturing, (accessed 3 June 2016) at http://www.buruenergy.com/canning-basin/hydraulic-fracturing-2/
[413] Above, note 395.
[414] Buru Energy, Buru Energy's proposed gas developments in the Canning Basin – Questions and Answers, March 2014, pg 13 at <http://www.buruenergy.com/wp-content/uploads/Proposed-Gas-Developments-QA1.pdf >

water use by the town of Broome or less than the water required to irrigate 1 hectare of crop annually.[415]

Operators in Western Australia and South Australia will face significant risk and challenges when they seek to use water to exploit shale and tight gas in the Canning and Cooper Basins. Amongst other things, they will need to protect water sources from contamination and consume an amount of water that the community finds palatable. Any demands operators place on communities for fresh water to carry out hydraulic fracturing will likely be opposed. The large volumes required will result in significant competition, between themselves, local inhabitants and agricultural interests. Having in place appropriate regulatory regimes to deal with water management is imperative.

2.3 Literature review: Community concerns with regulatory issues

According to some industry commentators, 'there exists little knowledge of or established consensus on best practice around the governance of unconventional gas development.'[416] The widespread hostility to shale and tight gas exploitation in the United States, in particular, is mainly due to concerns about the impact on water.[417] Not surprisingly, governments all over the world are under considerable pressure to develop regulatory regimes that are accepted, first and foremost, by the community.[418]

One industry commentator insists that the environmental risks linked to shale and tight gas exploitation, including from hydraulic fracturing can be managed subject to the establishment of robust regulatory regimes.[419] Shale and tight gas production is often characterised by the

[415] Buru Energy, Hydraulic Fracturing, (accessed 3 June 2016) at http://www.buruenergy.com/canning-basin/hydraulic-fracturing-2/

[416] Jarvis, M, 'Towards a Roadmap for Governance of Unconventional Gas: A Multidimensional Challenge' (2014) 12:3 *Oil, Gas & Energy Law* at < https://www.ogel.org/article.asp?key=3464> (assessed 23 November 2017)

[417] Accenture, Water and Shale Gas Development – Leveraging the US experience in new shale developments', 2012, 5 at <http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Water-And-Shale-Gas-Development.pdf>

[418] Brian G. Rahm & Susan J. Riha 'Evolving Shale Gas Management: Water resource risks, impacts, and lessons learned' (2014), *Environ. Sci. Processes Impacts* 1400, 1408 at <http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H>

[419] Allan Hawke AC, Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory, 2014, Executive Summary, page x.

use of 'old oil and gas regulations…because they have worked in the past'.[420] The literature clearly articulates that 'shale gas development, particularly its rapid pace and large scale, brings with it new risks, and new variations of old risks'.[421] Some industry commentators contend that using existing regulation designed to exploit conventional gas is unacceptable, as is the approach of simply adjusting it.[422]

The community concern with the exploitation of shale and tight gas and land access, water access and quality protection, regulation of well technology for drilling and hydraulic fracking and decommissioning and associated issues (abandonment, rehabilitation and reclamation) has been expressed in a number of recent parliamentary inquiries in Western Australia and South Australia.[423] It is highly likely the community and political antagonism toward shale and tight gas exploitation (particularly in Western Australia) will continue unless satisfactory alternatives are developed. There are numerous international studies that have examined the risks and challenges associated with exploiting shale and tight gas, though the author argues that none have dealt in a meaningful way with the specific shortcomings and regulatory gaps that the thesis contends exist in Western Australia and South Australia.

The majority of international studies have examined the United States' experience as a way of informing emerging nations of the conditions that helped them elicit a shale gas boom.[424] Others concentrate on the negative impacts of shale and tight gas exploitation, for example, water consumption, contamination, and land use and landscape issues.[425] A number argue that there are significant regulatory challenges with regard to well spacing, hydraulic fracturing, water management, landowner concerns, public concerns, environmental issues, regulatory

[420] Above, note 406 at 1409.
[421] Ibid.
[422] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, The University of Western Australia, 2014, pg 11
[423] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Report 42, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf and Natural Resources Committee, Inquiry into Unconventional Gas (Fracking) in the South East of SA, Final Report, One Hundred Nineteenth Report of the Natural Resources Committee, Tabled in the House of Assembly and ordered to be published 29 November 2016 at https://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=5&CId=341
[424] Wang, Z. & Krupnick, A., A Retrospective Review of Shale Gas Development in the United States: What Led to the Boom?, 2013 at http://www.rff.org/RFF/Documents/RFF-DP-13-12.pdf
[425] Tim Boersma & Corey Johnson, Risks and Potentials of Shale Gas Revolution, Consequences for Markets and the Environment, German Institute for International and Security Studies, SWP Comments 39, December 2012, pg 4.

processes, and information collection and dissemination.[426] With respect, Western Australia and South Australia's regulatory regimes are under-analysed and there are limited academic studies on the particular issues outlined in this thesis' introductory chapter (and above). Given that shale and tight exploitation is in its infancy in Western Australia and South Australia, understanding all the risk and challenges associated with it is difficult.[427]

Several years ago, one study concluded, quite rightly, that the literature on shale and tight gas exploitation 'on countries outside the United States and a few European states was rather thin'.[428] This shortcoming prompted the study's author to call for papers on the topic of governance of unconventional gas outside the United States for publication.[429] Of those received on the topic, none dealt with the myriad of issues examined in this thesis in the context of Western Australia and South Australia.[430]

The development of roadmaps and frameworks assist in guiding operators and informing stakeholders of the step-by-step process for potential development and the various 'good governance' interventions required at each stage of the value chain.[431] Both Western Australia and South Australia have released these documents in the last few years - the *Roadmap for Unconventional Gas Projects in SA*[432] and *Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia – A Whole of Government Approach*. [433]

Towards a Roadmap for Governance of Unconventional Gas: A Multidimensional Challenge argues that there is little knowledge of, or established consensus on best practice around the

[426] Energy Resources Conservation Board, Unconventional Gas Regulatory Framework - Jurisdictional Review (Report 2011-A), 2011 at https://www.aer.ca/documents/reports/r2011-A.pdf
[427] Brian G. Rahm & Susan J. Riha, 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci.: Processes Impacts* 1400, 1408 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H
[428] Andrews-Speed, Dr. P, 'OGEL Special: Governance of Unconventional Gas outside the United States' (2014) June 12:3 *Oil, Gas & Energy Law*
[429] *Oil, Gas and Energy Law Journal* (2014) June 12:3 at https://www.ogel.org/
[430] Andreas Goldthau, Michael LaBelle, 'OGEL Special: Governance of Unconventional Gas in Bulgaria' (2014) June 12:3 *Oil, Gas & Energy Law*; Silke M. Popp, OGEL Special: Unconventional Gas Regulation in Canada' (2014) June 12:3 *Oil, Gas & Energy Law*
[431] Jarvis, M, 'Towards a Roadmap for Governance of Unconventional Gas: A Multidimensional Challenge', (2014) June 12:3 *Oil, Gas & Energy Law*
[432] Energy Resources Division, Department of Manufacturing, Innovation, Trade, Resources and Energy, Roadmap for Unconventional Gas Projects in SA, 2012 at https:///www.statedevelopment.sa.gov.au
[433] [Department of Mines and Petroleum, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia – A Whole of Government Approach, 2015 Edition at https://www.DMIRS.wa.gov.au

governance of unconventional gas development globally.[434] This is certainly a fair statement. As pointed out by the Energy Resources Conservation Board, regulatory frameworks must be adapted to better manage unconventional gas and considerably different approaches are required if regulations are to remain relevant.[435] In *Shale Gas: A Review of the Economic, Environmental and Social Sustainability* it is suggested that 'in many nations, existing oil and gas regulations are currently thought to be sufficient, but new legislation is being introduced to tackle problems associated with shale gas that have arisen or could arise'.[436] However, the introduction of new legislation takes time.[437]

Dr Robb's regulatory proposal is a useful document for those interested in the exploitation of shale and tight gas and on matters to which this thesis has referred to, though it is not issue specific; rather it proposes a new regulatory framework.[438] With respect, it does not deal with specific jurisdictional solutions to land access, water use, drilling, hydraulic fracturing, decommissioning and rehabilitation explicitly. Western Australia and South Australia are both unlikely to introduce specific stand-alone unconventional gas legislation any time soon, if at all. Both jurisdictions have, at various times, amended their conventional gas legislation so they can manage the exploitation of unconventional gas.

2.3.1 Land Access

The thesis is primarily concerned with private land, leased land (pastoral, agricultural or other), land subject to a grant of title (petroleum) or native title land.[439] For some, the thought of operators entering their land to exploit shale and tight gas is profoundly distressing. Though many understand that they do not own the minerals on their land, 'the realisation that they are legally required to give access to their land to gas exploration companies and that those

[434] Jarvis, M, 'Towards a Roadmap for Governance of Unconventional Gas: A Multidimensional Challenge', (2014) June 12:3 *Oil, Gas & Energy Law*
[435] Eynon, G. et al. *Unconventional Resource Development and role of regulator (Energy Resources Conservation Board) (ERCB) Alberta.* (Canadian Society for Unconventional Gas & SPE Committee, October 2010).
[436] Jasmin Cooper, Lawrence Stamford, & Adisa Azapagic, "Shale Gas: A Review of the Economic, Environmental, and Social Sustainability" (2016) 4 *Energy Tecnol* 772, 785
[437] Ibid
[438] Simon Robb, 'A Best Practice Regulatory Proposal for Shale Gas Production', 2014, Faculty of Law, University of Western Australia
[439] Allnut, Liz, Australia: Rules and regulation of the oil and gas industry: Navigating the governance maze, 14 October 2015, Norton Rose Fulbright Australia

companies could, for example, construct roads, clear drilling sites, build work camps and, ultimately, construct gas production facilities, came as a profound shock.'[440]

Many Australians, particularly those in farming communities, mistakenly believe they enjoy an unqualified right to determine exactly who may enter or remain on their land and believe they exercise a virtually unassailable discretion to exclude individuals from trespassing on that land.[441] This is not the case. There are no laws in Western Australia or South Australia, constitutional or otherwise, that prohibit the exploration and production of shale and tight gas if the government considers it to be in the public interest.

In Australia, the multiple land use framework (the framework) recognises land access and land use conflict.[442] The framework asserts that '[by] reducing tensions that can arise between stakeholders, we achieve a better economic, social and environmental outcome that leads to sustainable outcomes for future generations.'[443] The framework features four desired outcomes, eight principles to guide land access and land use decisions and nine components that should be considered in planning, preparing and assessing land access and land use decisions.[444] The principles detailed in the framework give operators co-existing rights and interests with respect to land.[445] The framework was established with the resources and energy sectors in mind with the view that the concept would be extended to all sectors. The principle highlights that conflict arises according to land use needs and strategic objectives and it aids groups in addressing these challenges.

Land access regulation is primarily about government attempts to balance the rights of land holders and operators and to address community-wide costs and benefits that arise from exploration activities.[446] Disputes occur when the rights held by operator's impact the property

[440] Commonwealth Parliament, Senate, Standing Committee on Rural and Regional Affairs and Transport, Management of the Murray Darling Basin Interim Report: the impact of mining coal seam gas on the management of the Murray Darling Basin, 30 November 2011, pg 53.
[441] Kevin Gray & Susan Francis Gray, 'The Idea of Property in Land' in Susan Bright & John K Dewar (eds) *Land Law: Themes and Perspectives* (Oxford University Press, (1998) ,15-51 at 16 at https://trin-hosts.trin.cam.ac.uk/fellows/kevingray/870.pdf
[442] Standing Council on Energy and Resources, *Multiple Land Use Framework*, 13 December 2012, pg 1
[443] Id at 6.
[444] Standing Council on Energy and Resources, Multiple Land Use Framework, Background Document, December 2013 at <https://industry.gov.au/resource/Mining/Documents/MLUFBackgrounddocument.docx>
[445] COAG Energy Council, Multiple Land Use Framework, (accessed 18 September 2017) at http://www.scer.gov.au/workstreams/land-access/mluf/
[446] Productivity Commission, Non-Financial Barriers to Mineral and Energy Resource Exploration, 2013, pg 17

rights of landowners.[447] These issues are often settled by negotiation, i.e., conditions of access and compensation. It has been suggested that the financial incentive operators provide (compensation for damage or loss of earnings (or amenity)) minimises the impact of their activities.[448] In Western Australia, South Australia and Colorado, operators who intend to carry out activities on private land are encouraged to negotiate voluntary land access agreements.[449]

These types of agreements, particularly in Queensland, have been described, as a 'peculiar hybrid of contract, statute and property law.'[450] Ideally, access agreements should reduce the potential negative impacts on landholders.[451] Some argue that land access agreements are not ideal given they are essentially nothing more than a business to business transaction.[452] Further to this point, it is likely that, despite the best efforts of those involved, the following United Kingdom situation applies in Australia:

> …most rural landholders can be at some disadvantage due to: their limited experience in undertaking such negotiations compared to explorers, who may have negotiated hundreds of such agreements; the asymmetry of information regarding the potential impact of the exploration activity; and an imbalance or power, as in most cases, rural land holders are legally required to allow explorers to access their land.[453]

While this thesis is not examining the regulation of shale and tight gas in the United Kingdom, it is worth noting that they see land access as a real barrier to the industry.[454] Some have recommended that shale gas operators in the United Kingdom should have an automatic right of access so they can undertake horizontal drilling where it takes place at least 300 metres

[447] Ibid.
[448] Ibid.
[449] Department of Mines, Industry Regulation and Safety, Natural Gas from Shale and Tight Rocks, An overview of Western Australia's regulatory framework, February 2014, pg 7 <https://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-102D.pdf>
[450] Sharon Christensen, Pamela O'Connor, W D Duncan & Angela Phillips, 'Regulation of land access for resource development: A coal seam gas case study from Queensland' (2012) 21:110 *APLJ*, 31
[451] AMP Capital, Unconventional Gas Extraction, Its importance in the transition to a low carbon economy, insight paper, (accessed 18 July 2017) page 2 at http://www.ampcapital.com.au/AMPCapitalAU/media/contents/Articles/ESG%20and%20Responsible%20Investment/20150210-esg-unconventional-gas-extraction.pdf
[452] Productivity Commission, Non-Financial Barriers to Mineral and Energy Resource Exploration, 2013, pg 18 at < https://www.pc.gov.au/inquiries/completed/resource-exploration>
[453] Ibid.
[454] Ashurst Lawyers, Clearing the road for UK shale gas: a new land access regime (Energy, resources and infrastructure briefing, May 2014) at https://www.ashurst.com/publication-item.aspx?id_Content=10503

below the surface.[455] The basis of this right is the existing statutory right to access offered to coal operators in relation to underground operations.[456] Again, while not examining the regulatory regime of Queensland to manage coal seam gas and land access, it has been suggested that Queensland's current statutory regime for land access agreements is disjointed and does not fit with any established legal rules.[457]

The erosion, whether it is perceived or actual, of landowner 'rights', the strongly held view that compensation is inadequate and the power imbalances, whether real or perceived, in negotiations for entry to land for the purposes of shale and tight gas development all have the potential to lead to significant discontent in the community.[458] In order for exploitation to proceed smoothly, particularly in Western Australia, the issue of land access requires further examination.

Conflict often arises when the exploration rights held by operators seeking to exploit gas impact on the property rights held by landowners (or occupiers).[459] These conflicts tend to occur more so when the land is high value agricultural land, land around urban centres and other areas of high concentration land use.[460] Colorado once had the most wells (over 10 000) drilled in highly productive irrigated cropland and, as a consequence, dealt with a significant number of community complaints.[461] As a result of this conflict, surface owners' in Colorado strived to gain greater control over their land and compensation.[462]

Balancing the conflicting rights of those with an interest in land by addressing community-concerns associated with exploitation is particularly difficult.[463] The erosion of landholder rights, whether it is simply perceived by landholders or actually happens, the view, particularly by farmers that compensation is inadequate and the power imbalances between landholders

[455] Ibid.
[456] Ibid.
[457] Ibid.
[458] AMP Capital, Unconventional Gas Extraction, Its importance in the transition to a low carbon economy, insight paper, pg 3 athttp://www.ampcapital.com.au/AMPCapitalAU/media/contents/Articles/ESG%20and%20Responsible%20Investment/20150210-esg-unconventional-gas-extraction.pdf
[459] Productivity Commission, Non-Financial Barriers to Mineral and Energy Resources Exploration, 2013, pg 17
[460] Ibid.
[461] John Erich Johnson 'Gerrity Oil & Gas Corp. v. Magness: Colorado's Furtive Shift toward Accommodation in the Surface-Use Debate, Spring 1998' (2013) 33:3 *Tulsa Law Review*
[462] Ibid.
[463] Productivity Commission, Non-Financial Barriers to Mineral and Energy Resource Exploration, 2013, pg 17

and operators in negotiations all have the potential to, and often do, lead to significant discontent in local communities.[464] DMIRS may lead the world in regulating shale and tight gas exploitation because they are 'professional and have the necessary experience and processes to implement best practice in the regulation of unconventional natural gas.'[465] This means little to a concerned landholder dealing with an operator. Having the necessary experience and processes to implement best practice is not enough.

The Standing Committee of Environment and Public Affairs recommended, amongst other things, that the government draft legislation for a statutory framework for land access agreements.[466] Western Australia's Parliamentary inquiry determined that the state's citizens were nervous about the impact of shale and tight exploitation on agricultural land, native titleholders and its overall footprint.[467] The inquiry recommended that the Western Australia government establish a working group 'to draft legislation for a statutory framework for land access agreements between land owners and resource companies and should include provisions for an agreement template, compensation for land owners and the enforcement of mandatory access conditions.'[468] The role of the working group is to consider existing land access provisions for private land, consider other jurisdictions' land access arrangements for private land (legislative and non-legislative), suggest changes to Western Australia's farming land access agreement and make recommendations on a statutory framework for land access

[464] AMP Capital, Unconventional Gas Extraction, Its importance in the transition to a low carbon economy, insight paper, pg 3 at http://www.ampcapital.com.au/AMPCapitalAU/media/contents/Articles/ESG%20and%20Responsible%20Investment/20150210-esg-unconventional-gas-extraction.pdf

[465] Mining Australia, "WA DMIRS recognised as one of world's best resource regulators" Australian Mining news release 3 November 2013 from http://miningaustralia.com.au/news/wa-DMIRS-recognised-as-one-of-world-s-best-resources

[466] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Report 42, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf

[467] Id at Chapter 5, pg 75.

[468] Government of Western Australia, Response to recommendations of the Legislative Council Standing Committee on Environment and Public Affairs Report No.42 Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, 16 March 2016 at < http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/3913895c7a06d337d5c9ab7048257f79000e5c77/$file/tp-3895.pdf>

agreements.[469] The working group was to make a number of recommendations by 31 December 2017.[470]

The DMIRS considered the signing of a land access agreement in 2015 as historic.[471] The agreement outlines the 'rights and responsibilities of property owners and petroleum companies during negotiations over land access, and [will] include information on compensation, mediation and land rehabilitation'.[472] The Environment and Communications Legislation Committee inquiry into landholder rights was advised that 'ditches dug for pipe construction can make it difficult for farmers to traverse their property and can lead to livestock injuries.'[473] Landholders described to the Commonwealth inquiry how they faced complications when dealing with the gas companies, such as instances of discourteous approaches to accessing and navigating their land'.[474]

In the United States, shale and tight gas exploitation requires a significant number of small facilities some of which are, literally, in people's gardens.[475] Furthermore, exploitation is happening in residential areas and regions not typically accustomed to large scale oil and gas exploitation.[476] According to Professor Samantha Kennedy, in the Australia context, 'the exploitation of unconventional gas has generated considerable landowner antagonism'.[477] For example, the Lock the Gate Alliance argue that, amongst other things, the exploitation of

[469] Department of Mines and Petroleum, Western Australian Land Access Working Group, Terms of Reference, (accessed 19 May 2017) at http://www.DMIRS.wa.gov.au/About-Us-Careers/Western-Australian-Land-Access-20627.aspx

[470] Land Access Working Group established, Thursday 15 September 2016 at https://www.mediastatements.wa.gov.au/Pages/Barnett/2016/09/Land-Access-Working-Group-established.aspx

[471] Department of Mines and Petroleum, New gas agreement for agriculture sector, 3 November 2015 at < http://www.dmp.wa.gov.au/News/New-gas-agreement-for-16635.aspx>

[472] Ibid.

[473] Environment and Communications Legislation Committee inquiry into the *Landholders' Right to Refuse (Gas and Coal) Bill 2015*, (2015), pg 13-14 at < https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Gas_and_Coal/Report>

[474] Ibid.

[475] Hannah J. Wiseman, 'Hydraulic Fracturing and Information Forcing' (2013) 74 *Ohio State Law Journal* 87-97

[476] Katherine E. Konschnik & Mark K. Boling, 'Shale Gas Development: A Smart Regulation Framework' (2014) *Environmental Science & Technology* A

[477] Samantha Hepburn, 'Does Unconventional Gas Require Unconventional Ownership? An Analysis of the Functionality of Ownership Frameworks for Unconventional Gas Development' (2013) 8:1 *Journal of Environmental and Public Health Law* 44

unconventional gas causes a loss of productive farming land, reduced viability of farming operations and competition for scarce water resources.[478]

The Western Australia government has been urged to 'address the issue of conflicting land use and land access in its management of shale gas operations throughout the whole petroleum chain'.[479] Dr Hunter argues that these issues should be addressed through legislative provisions contained within the PGERA (objects clause) and a pre-emptive land use management strategy developed in consultation with relevant stakeholders and communities.[480] To date, none of this has occurred.

The Environment and Communications Legislation Committee (Federal Parliament), inquiry received a number of submissions that argued that compensation arrangements failed to deal with the imbalance in negotiating positions between landholders and operators.[481] Some insisted that the lack of negotiating power was 'very evident' and stemmed from an inability of some farmers to understand the often large amounts of information operators were providing them.[482] One operator is alleged to have offered a landholder $265 to develop wells and 'associated petroleum infrastructure'.[483] The landholder stated that 'No-one knows what

[478] Lock the Gate Alliance, Submission to the Standing Committee on the Environment and Public Affairs Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, (20 September 2013), pg 3 at < https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Gas_and_Coal/Report>

[479] Tina Hunter, Regulation of Shale, Coal Seam Gas and Tight Gas Activities in Western Australia, Final, An analysis of the capacity of the Petroleum and Geothermal Energy Act 1967 (WA) to regulate onshore gas activities in Western Australia, July 2011 at < https://epublications.bond.edu.au/law_pubs/419/>

[480] Department of Mines and Petroleum Response to Report: 'Regulation of Shale, Coal Seam and Tight Gas Activities in Western Australia', 2011, pg 4 – 8, 5 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-117D.pdf

[481] Environment and Communications Legislation Committee inquiry into the *Landholders' Right to Refuse (Gas and Coal) Bill 2015*,(2015) , pg 21 at < https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Gas_and_Coal/Report>

[482] Mr Leslie Manning, Director, p&e law, *Proof Committee Hansard*, 27 July 2015, pg 38 at < https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Gas_and_Coal/Report>

[483] Mr George Bender, Hopeland Community Sustainability Group, *Proof Committee Hansard*, 27 July 2015, pg 23 at < https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Gas_and_Coal/Report>

associated petroleum infrastructure is... It could mean anything... To allow them on for $265 was absolutely stupid.'[484]

Operators in Western Australia and South Australia will face significant risk and challenges when they seek to enter land to exploit shale and tight gas. Amongst other things, they will need to negotiate with landholders and others who a right to land. Any land access demands operators place on communities will likely be opposed. The land access required to exploit shale and tight gas will lead to significant competition. Having in place appropriate regulatory regimes to deal with water management is imperative.

2.3.2 Water access and quality protection

In Colorado the media argue that 'a new race for water is rippling through the drought-scorched heartland, pitting farmers against oil and gas interests, driven by new drilling techniques that use powerful streams of water, sand and chemicals to crack the ground and release stores of oil and gas.[485] One industry commentator in the United States insists that as a result of large scale drilling and chemical injection 'concerned citizens groups and the media have pointed to flaming tap water and have worried about chemical contamination; at the same time, industry representatives and many state regulators have sworn that the practice has never contaminated groundwater'.[486]

Most industry commentators argue that the handling and disposal of water is the single greatest environmental obstacle to shale and tight gas exploitation.[487] Most agree that shale and tight gas exploitation will threaten water resources in some way.[488] It is highly likely that Australia

[484] Ibid.
[485] For Farms in the West, Oil Wells are Thirsty Rivals, Sept 5, 2012 at http://www.nytimes.com/2012/09/06/us/struggle-for-water-in-colorado-with-rise-in-fracking.html?_r=0
[486] Hannah J. Wiseman, 'Risk and Response in Fracturing Policy' (2013) 84 *University of Colorado Law Review* 729, 729
[487] World Energy Outlook, Golden Rules for Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, (29 May 2012) pg 32 at http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf
[488] Hannah J. Wiseman, 'Hydraulic Fracturing and Information Forcing' (2013) 74 *Ohio State Law Journal* 87-97

will need to focus more on water than the United States given Australia has less surface water and relies heavily on groundwater.[489]

Some industry commentators insist that the negative impacts on water resources, if not properly managed, have the capacity to cause significant environmental and production issues beyond immediate production areas.[490] Those who are strongly opposed to shale and tight gas exploitation argue that there is a risk to drinking water supplies through contamination.[491] Water contamination can result from hydraulic fracturing fluid spills, waste water discharges, surface water and groundwater contamination by leaking wastewater impoundments; contamination of groundwater from poorly constructed or maintained wells, and freshwater depletion.[492] Some argue that the risk of groundwater contamination from shale and tight gas activities, including the use of hydraulic fracturing, is very low.[493] However, hydraulic fracturing can contaminate surface and groundwater through a number of pathways, the main being spills.[494]

Water can also be contaminated during earth-moving activities necessary for reclamation — both interim and final.[495] A poorly assembled well can result in contamination due to inadequate casing or cement failures.[496] The potential threat caused by seismic testing can be significantly diminished or removed by forcing operators to carry out seismic testing a safe distance from any water wells.[497]

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[489] Stephanie Neitzel, P.E. Esq. Principal WaterRich Advisors LLC, Centennial, Colorado, Water quality regulations for unconventional gas production, United States and Australia comparison, (accessed 12 June 2017) pg 7 at http://www.awa.asn.au/documents/136%20SNeitzel.pdf

[490] Ibid.

[491] Suzanne Goldenberg, 'Drinking water contaminated by shale gas boom in Texas and Pennsylvania' *The Guardian*, 16 September 2014 at <https://www.theguardian.com/environment>

[492] Katherine E. Konschnik & Mark K. Boling, 'Shale Gas Development: A Smart Regulation Framework' (2014) *Environmental Science & Technology* A

[493] Chamber of Mines and Energy South Australia , Submission to the Inquiry into the potential risks and impacts in the use of hydraulic fracture stimulation (Fracking) to produce gas in the South-East of SA Submission to Natural Resources Committee, Parliament of South Australia, (2015) pg 7

[494] Joel Minor, 'Local Government Fracking Regulations: A Colorado Case Study' (2014) 33 *Stanford Environmental Law Journal* 61, 71

[495] Intermountain Oil and Gas BMP Project, the Colorado Rural Water Association, AirWaterGas and Western Resource Advocates, Protecting source water in Colorado during oil and gas development, August 2016, pg 1 at http://www.oilandgasbmps.org/docs/CO186_ProtectingSourceWaterAugust2016.pdf

[496] Ibid.

[497] Ibid.

The Natural Resources Committee inquiry into unconventional gas argues that 'international and national data demonstrates that, by employing globally leading industry practice, risks of groundwater contamination can be effectively managed or avoided entirely.'[498] According to Geoscience Australia, the impacts on water from shale gas production are likely to be minimal apart from where there are more permeable rocks or structures present or where fracturing has an impact on aquifers.[499] They argue that the impact of extracting tight gas is negligible due to the small amount of water present, except where fracturing impacts on aquifers.[500]

As far as ACOLA is concerned, the risks to groundwater systems from hydraulic fracturing well failure is low to moderate, though the doubt about groundwater impacts is high.[501] They argue that there is moderate risk for water impacts related to the reduction in natural surface water flow (as a result of water abstraction and/or groundwater drawdown).[502] Given the shale and tight gas industry has changed so rapidly, ACOLA insist that this expansion has outpaced the availability of information for regulators to develop specific regulation.[503]

While it is possible to pinpoint a range of risks to groundwater and surface water, ACOLA insist that there is not enough scientific evidence to make claims robust, reliable and easy to use.[504] ACOLA suggest that 'there is a need to go beyond just identifying risks and start to acquire quantitative data on frequency and consequence of risks, with a view to developing a full risk management approach to environmental and related issues, for all shale gas projects.'[505]

[498] Inquiry into Unconventional Gas (Fracking) in the South East of South Australia, Final Report, One Hundred Nineteenth Report of the Natural Resources Committee, Tabled in the House of Assembly and ordered to be published 29 November 2016, p 12 at https://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=5&CId=295

[499] Minchin, Dr, S, Unconventional Gas and Water Resources in Australia, Geoscience Australia, (accessed 20 May 2017) pg 3 at http://www.water.anu.edu.au/pdf/2012/newsletter/sminchin.pdf

[500] Ibid.

[501] ACOLA Secretariat Limited, Shale Gas Development in Australia – Potential impacts and risks to ecological systems, 11 January 2013 at http://www.acola.org.au/PDF/SAF06Consultants/Eco%20Logical%20Risk%20and%20Impact%20Jan%202013.pdf

[502] Ibid.

[503] Ibid.

[504] Cook, P, Beck, V, Brereton, D, Clark, R, Fisher, B, Kentish, S, Toomey, J and Williams, J (2013). Securing Australia's Future – Engineering energy: unconventional gas production,pg 182 at http://www.acola.org.au/index.php/projects/securing-australia-s-future/project-6

[505] Ibid

The opposition to shale and tight gas exploitation due to water concerns in many parts of the United States and Western Europe is outlined succinctly in *'Water and Shale Gas Development – Leveraging the US experience in new shale developments'*.[506] The report insists that given the industry has changed so rapidly, it has often outpaced the availability of information for regulators to develop specific guidance.[507] The National Water Commission insists that opportunities exist to improve the management of water in unconventional mining by reducing regulatory burden and coordinating approaches to regulation.[508] A present there is no consistent approach to managing the use of water in shale and tight gas operations and the industry (and regulators) in Australia are effectively forced to cherry pick case by case individual 'best practice' mechanisms from an assortment of principles, rules and the laws designed to regulate the industry.

The Commonwealth's Office of Water Science commissioned, in 2015, two reports from the National Centre for Groundwater Research and Training[509] on the development of the shale and tight gas industry in Australia. The first review, largely scientific, related to induced seismicity, the creation of subsurface pathways, the depletion of shallow aquifers, groundwater contamination, the disposal of co-produced water (and salt) and surface spills.[510] The second review, legal in nature, provided a summary and comparative analysis of current regulatory regimes for shale and tight gas production at the state/territory and national levels and identified the current or potential gaps and proposed a best practice regulatory regime.[511] To date, neither has been publicly released.

The Council of Canadian Academies (CCA) insist that '…there is reason to believe that shale gas development poses a risk to water resources, but the extent of that risk, and whether substantial damage has already occurred, cannot be assessed because of a lack of scientific data

[506] Accenture, 'Water and Shale Gas Development – Leveraging the US experience in new shale developments', 2012, 5 at <http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Water-And-Shale-Gas-Development.pdf>
[507] Ibid.
[508] National Water Commission, Water for mining and unconventional gas under the National Water Initiative, (accessed 18 June 2016) at http://www.nwc.gov.au/__data/assets/pdf_file/0008/37691/Water-for-mining-and-unconventional-gas-under-the-National-Water-Initiative.pdf
[509] National Centre for Groundwater Research and Training at http://www.groundwater.com.au/
[510] National Centre for Groundwater Research and Training, The Impact of Unconventional Gas on Water Resources: Replacing Myths with Scientific Evidence, (12 May 2017) at http://www.petroleum.dmitre.sa.gov.au/__data/assets/pdf_file/0007/230947/Peter_Cook_-_Impact_of_Unconventional_Gas_on_Water_Resources_-_WG3.pdf
[511] Office of Water Science at http://www.groundwater.com.au/news_items/ncgrt-research-highlights

and understanding.'[512] The CCA insist that there are no proven or verified impacts on groundwater from shale and tight gas development.[513] Western Australia and South Australia must turn their attention to the regulatory regimes regarding the taking of water, the diversion of water and the use of water.[514]

There will be significant risks and challenges linked to shale and tight gas exploitation in Western Australia and South Australia. Regulatory regimes must be in place to protect water sources from contamination and operators will only be able to use an amount the community finds acceptable. Any demands operators place on communities will likely be opposed. The large volumes required will result in significant competition. Appropriate regulatory regimes must be in place to deal with water.

2.3.3 Regulation of well technology for drilling and hydraulic fracturing

An estimated 35 000 wells are hydraulically fractured in the United States every year and over one million have been hydraulically fractured since the first in the late 1940's.[515] ACOLA have suggested that '…based on the United States experience of well spacing, the proportional extent of fairways (highly prospective zones) and the size of prospective shale gas basins in Australia, in excess of 200,000 shale gas wells could be drilled'.[516]

Although the United States has a long history of successfully carrying out hydraulic fracturing operations, the increase in shale and tight gas exploitation has fuelled various stakeholder concerns.[517] Dr Allan Hawke AC argues that 'the environmental risks associated with

[512] Council of Canadian Academies, Environmental Impacts of Shale Gas Extraction in Canada, The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction, 2014 at http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/shale%20gas/shalegas_fullreporten.pdf
[513] Id at 96.
[514] Alex Gardner, Nick Duff, Kweku Ainuson & Samuel Manteaw, Regulating Mining Water Use and Impacts in Ghana: Comparing Australian and Ghanaian Law for Reform Ideas, July 2015, pg 7
[515] Water Management Associated with Hydraulic Fracturing, Upstream Segment, API Guidance Document HF2 First Edition, June 2010, pg vi
[516] Frogtech Pty Ltd, Potential Geological Risks Associated with Shale Gas Production in Australia, Melbourne: Australian Council of Learned Academics, 2013, pg 6 at <http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf>
[517] Daniel Steinway, 'Hydraulic Fracturing and the Shale Gas Boom' (2012) 5 *IELR* 180-182

hydraulic fracturing can be managed effectively subject to the creation of a robust regulatory regime'.[518] A submission to the Standing Committee on Environment and Public Affairs argued that 'hydraulic fracturing for unconventional gas in Western Australia is not in the public interest…is completely unacceptable and should be permanently banned.'[519] Another submitted 'that WA does not need to proceed down the path of fracking for onshore unconventional gas…The impacts are serious, the risks severe, the consequences irreversible and the safe, sustainable alternatives are clear and available'.

One industry observer group, Frogtech, insist that hydraulic fracturing should be 'prohibited (or minimised) in areas where users of productive arable land rely, whether now or in the future'[520] and if it must be used that 'it be extracted from the lowest quality available…land is rehabilitated to support improved biodiversity condition and ongoing monitoring'.[521] Shale and tight gas production in the United States has exposed, amongst other things, well integrity concerns.[522]

The International Energy Agency suggest that rules that deal with well design, construction, cementing and integrity testing to prevent leaks into aquifers must be accompanied by rigorous assessments, monitoring and handling of water requirements.[523] Some insist that 'the specific process of hydraulic fracturing or "fracking" in deep shale, properly managed and regulated, is unlikely to pose significant risks to groundwater, but other processes associated with unconventional gas extraction, including mid to long-term well bore integrity, surface spills, and waste and chemical transport, present risks that need to be properly considered and managed.'[524]

[518] Allan Hawke AC, Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory, 2014, Executive Summary, page x
[519] Julian Sharp, Submission, Inquiry into the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas, 23 August 2013
[520] Vic Andrich, Submission, Inquiry into the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas, 18 September 2013
[521] Ibid.
[522] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013, pg 4 at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf
[523] World Energy Outlook, Golden Rules for Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, (2012) at 17 at http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf
[524] Natural Resources Committee, Inquiry into Unconventional Gas (Fracking) in the South East of SA, Final Report, One Hundred Nineteenth Report of the Natural Resources Committee, Tabled in the House of Assembly and ordered to be published 29 November 2016, p 12

Well integrity comprises pressure and fluid containment during well operations, including during hydraulic fracturing, the adherence to industry standards and ensuring that fracture fluid and gas production is confined within the reservoir rock and well bore.[525] Wells must be constructed to prevent gas from migrating into fresh water formations. A properly constructed well protects drinking water aquifers during shale and tight gas operations.[526]

Maintaining the integrity of wells is vital to production. A well that is maintained isolates internal conduits from the surface and subsurface and confines the wells produced fluid to a production conduit within it.[527] Well integrity is the key to protecting underground water resources[528] and has four aspects. Namely, the evaluation of stratigraphic confinement, the specification of well construction standards, the evaluation of mechanical integrity, and the monitoring of hydraulic fracturing and the monitoring of producing wells.[529]

Well design and well integrity are vital to protecting water resources as operators' drill into gas-bearing formations. The most important aspect of hydraulic fracturing is well integrity.[530] Well integrity protects groundwater from wells' contents during horizontal drilling and horizontal fracturing through a combination of steel casing, cement casing and mechanical isolation devices fitted as a part of the construction process.[531]

[525] Energy Resources Division, Department of the Premier and Cabinet, Gas and Oil in Unconventional Reservoirs in the South East of South Australia, Version 27/07/17, pg 7 at https://petroluem.statedevelopment.sa.gov.au

[526] Intermountain Oil and Gas BMP Project, the Colorado Rural Water Association, AirWaterGas and Western Resource Advocates, Protecting source water in Colorado during oil and gas development, August 2016, pg 1 at http://www.oilandgasbmps.org/docs/CO186_ProtectingSourceWaterAugust2016.pdf

[527] American Petroleum Institute, Hydraulic Fracturing Operations— Well Construction and Integrity Guidelines, API guidance document hydraulic fracturing, 1st Edition, October 2009, pg 1 at http://www.shalegas.energy.gov/resources/HYDRAULIC FRACTURING 1.pdf

[528] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 29 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF

[529] Ibid.

[530] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Implications for WesternAustralia of Hydraulic Fracturing for Unconventional Gas, November 2015, pg 144 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-109D.pdf http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf

[531] American Petroleum Institute, Hydraulic Fracturing Operations— Well Construction and Integrity Guidelines, API guidance document, hydraulic fracturing, 1st Edition, October 2009, pg 2 at http://www.shalegas.energy.gov/resources/HYDRAULIC FRACTURING 1.pdf

Properly constructed wells minimise the potential of fluids migration into drinking water aquifers.[532] Both horizontal drilling and hydraulic fracturing prevent gas and water from migrating between different formations penetrated by a wellbore.[533] A shale and tight gas well should be designed to prevent interconnection between gas reservoirs and water aquifers in order to ensure formation fluids are confined to the well, that there is no leakage and to prevent substances from being introduced to the well that may cause environmental harm.[534]

After drilling commences, it stops at various points so that purpose-built steel pipes (casing) can be fitted.[535] The space between the casing and borehole wall is lined with cement that provides a non-porous barrier preventing cross-contamination between gas bearing formations and overlying aquifers.[536] The wellhead which contains barriers, valves, seals and a gas/water separator is positioned on the surface to maintain control of the well.[537] The wellhead also incorporates a means of hanging the production tubing and installing the Christmas tree (a vertical assembly of mechanical elements used in oil exploration and production in surface and underwater oil and gas wells, primarily for flow control)[538] and surface flow-control facilities in preparation for the production phase of the well.[539]

[532] Mr David Guglielmo, Country Manager, Halliburton Australia Pty Ltd, Transcript of Evidence, 10 February 2014, p 2.
[533] Engineering Unit – Wellbore Integrity, COGCC, Department of Natural Resources, (accessed 19 January 2018) at https://cogcc.state.co.us/documents/about/TF_Summaries/GovTaskForceSummary_Engineering%20Wellbore%20Integrity.pdf
[534] Santos, Drilling and Well Integrity, Technical Fact Sheet, Unconventional Gas Mining, Submission 57 – Attachment 1, 2016, pg 6 at http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Gasmining/Gasmining/Submissions
[535] Shale gas in Australia, Drilling and well construction, (accessed 21 June 2017) at http://www.shale-gas.com.au/industry-operations/drilling-well-construction/
[536] Ibid.
[537] Ibid.
[538] Investopedia, Christmas tree (oil and gas), (accessed 12 May 2017) at http://www.investopedia.com/terms/c/christmas-tree-oil-and-gas.asp
[539] Wellhead, Schlumberger Oilfield Glossary, (accessed 12 June 2017) at http://www.glossary.oilfield.slb.com/Terms/w/wellhead.aspx

The following diagram shows well casing and cements layers:

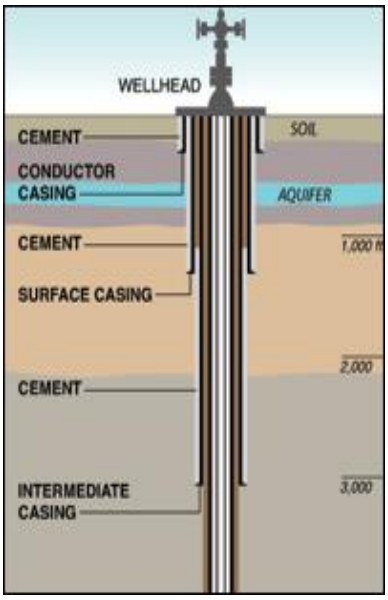

Figure 6 Well casing and cement layers[540]

The conductor casing inhibits loose surface sediment from failing into the well and protects surface aquifers.[541] Conductor casing is roughly 50m deep and placed into the surface hole and cemented along its full length to ground surface.[542] The surface casing protects groundwater and is set below the potable aquifers where the blowout preventer is installed on the well.[543] This casing is typically set at 800m deep and is cemented to the surface.[544] The intermediate casing isolates unstable whole sections, lost-circulation zones, low-pressure zones and production zones.[545] Intermediate casing is typically used for deeper wells to manage hole

[540] State of New Mexico, Oil and Gas Well Information, (accessed 12 May 2018) at http://www.emnrd.state.nm.us/OCD/education.html
[541] Department of Mines and Petroleum, Well design and integrity, Petroleum information sheet, 2015, pg 1 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-109D.pdf
[542] Encana, Wellbore construction, (accessed 18 July 2017) at https://www.encana.com/sustainability/environment/water/protection/construction.html
[543] Department of Mines and Petroleum, Well design and integrity, Petroleum information sheet, 2015, pg 1 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-109D.pdf
[544] Ibid.
[545] PetroWiki, Casing and tubing, (accessed 14 July 2017) at http://petrowiki.org/Casing_and_tubing#Surface_casing

conditions when drilling to a targeted formation.[546] The production casing or liner is the last casing in a well and it runs from total depth to the surface. Liners run from the total depth to a suitable overlap inside the previous casing.[547] Production tubing is fitted inside the casing to act as a conduit during production.[548]

In 2011, the Australian Petroleum Production Exploration Association (APPEA) released a Code of Practice for Hydraulic Fracturing applicable to onshore gas in Western Australia.[549] The code was developed by operators based on proven operating principles and leading practices in other jurisdictions relevant to local conditions. The code supported the public release of information, subject to the protection that the National Industrial Chemicals Notification and Assessment Scheme provided for commercially sensitive information.[550]

The code contains seven guidelines. The aim of guideline one was to guarantee that operators communicated openly and as early as possible with interested parties.[551] This involves describing risk management strategies to minimise any potential unwanted or adverse impacts.[552] Guideline two was aimed at ensuring that well design and performance practices include protecting aquifers and groundwater that may be used for commercial or residential water supply.[553]

The aim of guideline three was to protect and responsibly use groundwater resources.[554] For example, where appropriate, all water used in hydraulic fracturing operations will be recycled and/or reused, taking water from aquifers will be subject to Department of Water and Environment Regulation (DoWER) licence requirements.[555] The aim of guideline four is to reduce the use of chemicals in hydraulic fracturing operations, provide accurate information

[546] Department of Mines and Petroleum, Well design and integrity, Petroleum information sheet, 2015, pg 1 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-109D.pdf
[547] Ibid.
[548] Ibid.
[549] Australia Petroleum Production Exploration Association, Code of Practice for Hydraulic Fracturing, Western Australian Onshore Gas, (accessed 18 April 2017) at http://www.newstandard.com.au/wp-content/uploads/2011/11/APPEA_Code_of_Practice.pdf
[550] Ibid.
[551] Id at 2.
[552] Ibid.
[553] Ibid.
[554] Id at 3.
[555] Ibid.

on any chemical use and promote the safe and responsible use of chemicals.[556]. The aim of guideline five to ensure that post-fracture stimulation clean-up flowback or produced fluids cannot come into contact with production aquifers or pollute soil or soil substrate. Guideline six aims to ensure the fugitive emissions from stimulated wells during flowback and testing activities are minimised. The aim of guideline seven is to ensure continuous performance improvement and the sharing of information with regulators and other stakeholders to reduce potential risks of hydraulic fracturing.[557]

According to the DMIRS, Western Australia has the most stringent well integrity and resource management conditions in Australia following the introduction of new regulations for shale and tight gas.[558] DMIRS believe the state is well placed to learn from experiences in other jurisdictions and to adopt international best practice standards to further strengthen their robust regulatory system ensuring the environment and communities are protected as this new industry is developed.[559] The Natural Resources Committee found that while hydraulic fracturing was unlikely to pose significant risks to groundwater, other processes, including mid to long-term well integrity, surface spills and waste and chemical transport, presented risks that needed to be properly considered.[560]

2.3.4 Decommissioning and associated issues

The DMIRS consider 'decommissioning' to mean 'take out of service' and note that it is not generally defined in legislation.[561] The DMIRS insist that 'this may be a contributing factor to its confusion with terms such as 'removal' and 'disposal', which are two possible processes applied in decommissioning, and sometimes also with 'abandonment'.[562]

[556] Ibid.
[557] Id at 4.
[558] Department of Mines, Industry Regulation and Safety, New Resource Management Regulations, 1 July 2015 at http://www.DMIRS.wa.gov.au/7105_21668.aspx
[559] Department of Mines, Industry Regulation and Safety, New Resource Management Regulations, 1 July 2015 at http://www.DMIRS.wa.gov.au/7105_21668.aspx
[560] Natural Resources Committee, Inquiry into Unconventional Gas (Fracking) in the South East of South Australia, Final Report, One Hundred Nineteenth Report of the Natural Resources Committee, Tabled in the House of Assembly and ordered to be published 29 November 2016, p 12 at https://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=5&CId=341
[561] Department of Mines, Industry Regulation and Safety, Government of Western Australia, Petroleum Decommissioning Guideline, 30 October 2017 , pg 2 at www.dmirs.wa.gov.au
[562] Ibid.

The DMIRS define 'decommissioning as the controlled process of retiring a petroleum operation from service in a manner that is safe and environmentally responsible, followed by regulated removal of property from the licence or permit area, and the rehabilitation of the environment to the approved state.'[563] The process can also comprise 'the partial or progressive removal of facilities from a field as conditions change, or offtake rates decline and the ultimate cessation of production is foreshadowed.'[564]

> The practice of safely decommissioning a well, dismantling facilities and rehabilitating land to its natural state or some other form desired by society has been common practice in the petroleum industry for many decades and the industry has developed state-of-the-art skills in performing this function.[565]

It is estimated that around 2.6 million gas wells have been drilled in the United States since 1949.[566] Two decades ago, there were about 1.2 million abandoned oil and gas wells in the United States, 200 000 of them unplugged.[567] Many states in the United States have found it difficult to plug wells at the rate at which they are abandoned.[568] The state of New York plugged 25 percent of its abandoned wells in 2010, down from 27 percent in 1994.[569] Texas

[563] Ibid.
[564] Ibid.
[565] Parliamentary Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, Submission for the Chamber of Minerals and Energy Western Australia, September 2013, pg 38 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/99D8D0023E339C6F48257C4000110456/$file/ev.fra.131004.sub.112.the+chamber+of+minerals+and+energy+of+western+australia.pdf
[566] US Energy Information Administration, Crude Oil and Natural Gas Exploratory and Development Wells, (accessed 18 July 2017) at http://www.eia.gov/dnav/ng/ng_enr_wellend_s1_m.htm
[567] EPA, Management of Wastes from the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy. Office of Solid Waste and Emergency Response, Washington, D.C, 1987 at < https://nepis.epa.gov/Exe/ZyNET.exe/20012D4P.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1986+Thru+1990&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C86thru90%5CTxt%5C00000015%5C20012D4P.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL>
[568] RJ Davies et al, 'Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation' (2014) *Marine and Petroleum Geology* 9
[569] Ibid.

has an 'aggressive program' for plugging abandoned wells and plugged more than 41 000 between 1991 and 2009 as part of its well plugging program.[570]

Decommissioning is becoming a rapidly developing industry particularly worldwide.[571] Given Western Australia's level of well immaturity and numbers, none have reached their economic limit and ceased production, though more fields are now being identified and preparing for decommissioning.[572]

All wells will eventually become unproductive and should be plugged.[573] Plugging and abandoning has not changed substantially over the past 100 years and while there have been improvements in the quality of the materials used and changes to the methods employed to plug wells, there have not been specific variations that have elevated the technology of plugging wells.[574] Plugging and abandoning wells that are no longer viable, or have wellbore issues and require closure, has traditionally been conducted as an afterthought.[575]

A recent analysis of Colorado's 98 223 wells revealed that 45 007 were suitable for final reclamation, meaning that they had been plugged and abandoned, drilled and abandoned without production (i.e., dry and abandoned wells) or permitted but never drilled (i.e., abandoned locations).[576] Of the 45 007 wells, 26 322 (58 percent) passed a final reclamation inspection and were considered closed with the remaining 18 685 in different stages of reclamation and awaiting final inspection.[577]

[570] Ibid.
[571] Department of Mines, Industry Regulation and Safety, Government of Western Australia, Petroleum Decommissioning Guideline, 30 October 2017 , pg 2 at www.dmirs.wa.gov.au
[572] Ibid.
[573] Plugging and abandonment of oil and gas wells, prepared by the Technology Subgroup of the Operations & Environment Task Group, Paper #2-25, Working Document of the NPC North American Resource Development Study, 15 September 2011, pg 117
[574] Id at 19.
[575] Id at 6.
[576] Colorado Oil and Gas Conservation Commission, Department of Natural Resources, Final Reclamation Inspection and Implementation Program: A Status Report to the Commission, December 2015, pg 2 at https://cogcc.state.co.us/Announcements/Final_Reclamation_Report_20151208.PDF
[577]Ibid.

Decommissioning is one of the final stages in a wells' service life.[578] Decommissioning is undertaken to isolate and protect fresh water and gas bearing zones, to prevent leaks from or into wells and involves removing surface structures in order to rehabilitate land.[579] The term decommissioning is used interchangeably with 'plug and abandon' and 'abandonment' and involves preparing wells for permanent closure.[580] Abandoned, idle and orphaned denotes wells where an operator has failed to locate commercial quantities of gas; wells have become unproductive or are 'without an owner'.

An orphaned well is deemed abandoned when an operator chooses not to claim responsibility for it or where an owner cannot be found.[581] For example, if an operator goes bankrupt or a well becomes orphaned in Wyoming, the state becomes responsible for future management.[582] Broadly speaking, well abandonment involves an operator cementing and capping a well to minimise the threat it may pose to, amongst other things, water resources.[583]

An uncapped or incorrectly sealed well can adversely impact public health, safety and the quality of groundwater resources in the vicinity.[584] Plugging ensures that gas, water, and other substances that facilitate extraction are quarantined to their original reservoir.[585] Decommissioning inhibits spills, water contamination, and the release of dangerous gas.[586] The isolation of permeable gas bearing formations protects underground resources, prevents

[578] Department of Environmental Protection, Pennsylvania, Well abandonment procedures, Chapter 7, (accessed 19 June 2017) at https://www.dep.state.pa.us/dep/deputate/watermgt/Wc/Subjects/SrceProt/ground/sympos/GrdMonitor-chap7.htm

[579] Department of Mines and Petroleum, Government of Western Australia, Closure and decommissioning, (accessed 19 May 2017) at http://www.DMIRS.wa.gov.au/Petroleum/Closure-and-decommissioning-8667.aspx

[580] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Report 42, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, pg 151 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf

[581] Id at 5.

[582] Stephanie Joyce, Wyoming Public Radio & Jordan Wirfs-Brock, The Rising Cost of Cleaning Up After Oil and Gas, [DATE OR DATE VIEWED?] at http://insideenergy.org/2015/10/01/the-rising-cost-of-cleaning-up-after-oil-and-gas/

[583] P Cook, V Beck, D Brereton, R Clark, B Fisher, S Kentish, J Toomey & J Williams, Engineering Energy: Unconventional Gas Production, Report for the Australian Council of Learned Academies, May 2013, p 176

[584] Department of Environmental Protection, Pennsylvania, Well abandonment procedures, Chapter 7, (accessed 13 June 2017) at https://www.dep.state.pa.us/dep/deputate/watermgt/Wc/Subjects/SrceProt/ground/sympos/GrdMonitor-chap7.htm

[585] Rule 319(a)(1) of the COGCC rules

[586] Stan Olmstead, Report of oil & gas well abandonment and reclamation on federal lands administered by BLM-Utah, 2015, pg 1 at http://www.peer.org/assets/docs/blm/3_30_15_Utah_well_report.pdf

potential contamination of potable water sources and prevents surface leakage.[587] Plugging encompasses sealing the wellbore at various depths to avoid possible contamination of aquifers or formations outside the producing formation.[588]

In order to decommission a well, the production zone is insulated with a cement plug[589] and barriers are placed within the well casing to ensure no fluids can enter or exit the well once the wellhead is disconnected.[590] Although cement is predominantly used to seal wells, drilling mud, bentonite, and mechanical plugs also are used in conjunction with cement.[591] Given fracking depends on cement to guarantee well integrity, and isolation from aquifers, great care must be taken to ensure a perfect seal that lasts long after a well ceases production.[592]

An operator who abandons a well must restore the natural integrity of the formation that was pierced by the wellbore.[593] A well that is incorrectly abandoned provides a pathway for brines, gas or other fluids to migrate up the well and into shallow drinking water aquifers or to the surface.[594] An abandoned well usually contains a surface casing that extends to depths below a drinking water aquifer, and a (set of) production string(s) running to the target formation.[595]

[587] Global CCS Institute, Well plugging and abandonment techniques, (accessed 18 October 2017) at https://hub.globalccsinstitute.com/publications/long-term-integrity-co2-storage-%E2%80%93-well-abandonment/2-well-plugging-and-abandonment
[588] Colorado State University, Oil and Gas Development in Colorado, Extension, Consumer Series, Fact Sheet No. 10. 639, (accessed 12 May 2017), pg 5 at http://extension.colostate.edu/docs/pubs/consumer/10639.pdf
[589] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework, Shale and Tight Gas in WA, A Whole of Government Approach, 2015 Edition, pg 31 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf
[590] Id at 21.
[591] Above, note 574.
[592] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, Submission 43 from Sven Borg, 18 September 2013, p 16
[593] Global CCS Institute, Well plugging and abandonment techniques, (accessed 18 October 2017) at https://hub.globalccsinstitute.com/publications/long-term-integrity-co2-storage-%E2%80%93-well-abandonment/2-well-plugging-and-abandonment
[594] Ibid.
[595] Ibid.

The term 'rehabilitation' is used interchangeably with 'reclamation'.[596] Land is considered rehabilitated when it is returned to its prior condition.[597] There are a various number of different motivations for returning non-productive well sites and associated land to pre-operation conditions i.e. environmental and multiple use concerns.[598] Decommissioning is becoming increasingly more important as a result of the high costs involved which impact on the fiscal limits and the life of a field.[599]

2.4 Conclusion

Shale and tight gas has emerged as a significant energy source for those countries willing and able to exploit it. In most countries, this willingness is meet with apprehension, particularly in relation to land access, water access and quality protection, the regulation of wells for hydraulic fracturing and decommissioning and associated issues. The aim of the chapter was to provide context to the regulatory review.

This chapter provided the context for the comparative regulatory analysis that will be undertaken in Chapter 4. It defined shale and tight gas and examined the production stages and production methods required to exploit shale and tight gas i.e. horizontal drilling and hydraulic fracturing, the footprint of shale and tight gas operations and he impact on ground and surface water. This chapter defined resource classifications, summarised Australia's shale and tight gas prospectivity and examined the role of water, volume required and availability in Australia.

The chapter encompassed a literature review that focused on the community concerns with shale and tight exploitation and the key regulatory issues. There is no consistent approach to regulating the exploitation of shale and tight gas. The knowledge gaps are significant and likely the result of Western Australia and South Australia disregarding what has happened in the

[596] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Report 42, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, pg 150 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf

[597] Ibid.

[598] Stan Olmstead, Report of oil & gas well abandonment and reclamation on federal lands administered by BLM-Utah, 2015, pg 1 at http://www.peer.org/assets/docs/blm/3_30_15_Utah_well_report.pdf

[599] Department of Mines, Industry Regulation and Safety, Government of Western Australia, Petroleum Decommissioning Guideline, 30 October 2017, pg 2 at www.dmirs.wa.gov.au

United States when developing their regulatory regimes. This thesis distinguishes itself from the existing Australian literature by presenting a comparative analysis which focuses on land access, water use, drilling, hydraulic fracturing, decommissioning and rehabilitation in Western Australia, South Australia and Colorado. Much of the focus in Australia to date has been on coal seam gas exploitation and mining.[600] The lack of attention given to the exploitation of shale and tight gas is a primary reason for the need for a regulatory review at this time. Prior to the emergence of the coal seam gas industry on the east coast of Australia, the interaction of petroleum legislation with water resources legislation, and water impacts generally caused less concern than the water impacts from mining.

Western Australia, South Australia and Colorado all have diverse regimes to manage shale and tight gas exploitation. While regulatory diversity by itself is not a significant problem (and not overly surprising) the question of whether it is appropriate when it comes to regulating certain aspects of exploitation depends largely on whether it is embedded in underlying differences.[601] There are certain aspects of regulation that should not be treated differently simply because exploitation is occurring in another jurisdiction.

The way in which jurisdictions regulate the exploration, production and abandonment of shale and tight gas is clearly more heterogenous than homogenous.[602] The 'heterogeneity of shale gas regulations is pervasive; it can be seen in what states regulate and how stringently they do so'.[603] The absence of a national framework similar to the one for coal seam gas[604] reinforces the view that Australia has a 'wait and see' approach when it comes to a regulatory regime for shale and tight gas.

Notwithstanding this heterogeneity in shale gas regulation, and the lack of an Australian national consensus on a regulatory regime for shale gas, there is value in undertaking a comparative analysis of the three respective regimes. This chapter has identified four key issues

[600] Ibid.
[601] Nathan Richardson, Madeline Gottlieb, Alan Krupnick& Hannah Wiseman, The State of State Shale Gas Regulation, Executive Summary, May 2013, pg 5
[602] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, The University of Western Australia, 2014, pg 84
[603] Nathan Richardson, Madeline Gottlieb, Alan Krupnick & Hannah Wiseman, The State of State Shale Gas Regulation, Executive Summary, May 2013, pg 5
[604] The National Harmonised Regulatory Framework for Natural Gas from Coal Seams 2013, Standing Council on Energy and Resources at http://www.scer.gov.au

of regulatory attention that have generated significant community concern in all three jurisdictions being studied: land access, water access and quality protection, well technology for drilling and fracking, and decommissioning and rehabilitation of associated land uses. These issues are the subject of the comparative regulatory review in Chapter 4.

The next chapter provides a brief history of mineral and petroleum ownership which includes an examination of indigenous rights. The chapter also examines regulatory approvals focusing on environmental approvals and assessment. Chapter 3 also examines the various regulatory approaches that can be used to manage the exploitation of shale and tight gas.

3 TENURE, APPROVALS AND REGULATORY APPROACHES

3.1 Introduction

Australia's mineral and petroleum resources within three nautical miles offshore are held by the Crown in the right of the States and Territories. The State and Territory Parliaments have passed laws to manage land allocation (which typically withholds mineral and petroleum rights to the Crown), and to allocate those mineral and petroleum exploration and production rights separately from land title.[605] The minerals and petroleum legislation also provides for the rights holders to gain access to and over the surface of the land (held by others) in order to exercise their rights.

Being able to access and use land is essential for the development of commerce, including agriculture, manufacturing, mining, and shale and tight gas.[606] The Commonwealth Parliament's Environment and Communications Legislation Committee inquired into land access and unconventional gas exploitation, arguing that 'the tension that can exist between landholders and resource companies is a consequence of Australia's system of mineral rights'.[607] Many land owners mistakenly believe that they enjoy an absolute right to determine precisely who may enter or remain on their land, and may exclude any persons from trespassing on that land.[608]

This chapter examines land and mineral and petroleum rights in Western Australia, South Australia and Colorado. It will do this by examining the various tenure regimes in terms of resource ownership, the petroleum entitlement system, regulatory approvals and environmental assessment. The chapter will also examine the regulatory approaches each jurisdiction uses to

[605] Department of Industry, Innovation and Science, Unconventional Gas, (accessed 28 May 2017) at https://industry.gov.au/resource/UpstreamPetroleum/Pages/UnconventionalGas.aspx

[606] Department of Mines, Industry Regulation and Safety, Land use and access, (accessed 18 June 2017) at http://www.dmp.wa.gov.au/Petroleum/Land-use-and-access-20009.aspx

[607] Environment and Communications Legislation Committee inquiry into the *Landholders' Right to Refuse (Gas and Coal) Bill 2015*, (5 March 2015), pg 16 at https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Gas_and_Coal

[608] Tina Hunter, Land Access on Private Land for Mineral and Petroleum Activities, A review of existing provisions in Australian states and Territories and selected overseas jurisdictions, February 2017, pg 8

manage the exploitation of shale and tight gas. This includes the risk based approach, objective based approach, command and control and case by case permitting.

3.2 Mineral and petroleum ownership

The Crown in the right of the States and Territories owns mineral and petroleum resources in their natural locations. The public ownership of minerals is common to most former British colonies and has been and is an important source authority to approve and regulate resource exploitation in return for payment of public royalty revenue. The exploitation of mineral and petroleum resources is generally undertaken by private commercial resources companies or joint ventures under authority from the state or territory governments on condition of payments of royalties.

There are two common forms of interests in land: crown leasehold interest[609] and freehold (private ownership) interest.[610] Crown leasehold land is land that is leased to a person or company by the state (as the Crown).[611] There are different forms of leasehold tenure - two thirds of Crown-owned land in northern Australia is under pastoral leasehold.[612] Freehold land offers the most complete form of land ownership (in perpetuity) and it allows land holders to deal with the land including selling, leasing, licensing or mortgaging the land, subject to compliance with applicable laws such as planning and environment laws.[613]

The ownership of everything linked with land is not absolute, as the States, Territories and Commonwealth can withhold certain rights, such as the right to use minerals or petroleum.[614] As pointed out by one industry commentator:

[609] Austrade, Leasehold land, What does title mean? , (accessed 15 April 2018) at < https://www.austrade.gov.au/land-tenure/land-tenure/leasehold-land>
[610] Austrade, Freehold land, What does title mean?, (accessed 15 April 2018) at < https://www.austrade.gov.au/land-tenure/land-tenure/freehold-land>
[611] Austrade, Leasehold land, What does title mean?, (accessed 15 April 2018) at < https://www.austrade.gov.au/land-tenure/land-tenure/leasehold-land>
[612] Ibid.
[613] Austrade, Freehold land, What does title mean?, (accessed 15 Aprill 2018) at < https://www.austrade.gov.au/land-tenure/land-tenure/freehold-land>
[614] Ibid.

> The common law scope of private land ownership has been modified by legislation enacted in each state and territory which purports to vest the ownership of minerals and resources back to the state. Indeed, all Australian states and the Northern Territory have legislatively declared that petroleum in situ is owned, without exception, by the Crown regardless of when the land containing the petroleum passed into private ownership.[615]

Australia's common law position was altered by state and territory mining and petroleum legislation.[616] The outcome has been a rejection of the notion of private ownership of minerals based on land ownership and, instead, the adoption of a policy of statutorily reserving all minerals and petroleum from future Crown grants of land.[617] There are, however, a small number of operational mining leases in Western Australia granted before 1899 that provide for private ownership of minerals except for the 'royal metals of gold and silver'.[618]

The PGERA states that, 'petroleum, geothermal energy resources and geothermal energy on or below the surface of all land within this State, whether alienated in fee simple or not so alienated from the Crown, are and shall be deemed always to have been the property of the Crown'.[619] The exploration and production of shale and tight gas in Western Australia is principally the responsibility of the State Minister for Mines and Petroleum through the DMIRS. The discovery and development is carried out by the private sector in line with a system of access rights to resources which assists operators and provides long term community benefits. Similarly, in South Australia, 'property in petroleum and other regulated resources is vested (or continues to be vested) in the Crown...on the production of petroleum, or some other regulated substance, by a person lawfully entitled to produce the petroleum or other regulated substance, it becomes the property of the person who produced it.'[620]

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[615] Environment and Communications Legislation Committee inquiry into the *Landholders' Right to Refuse (Gas and Coal) Bill 2015*, (2015), Professor Samantha Hepburn, Submission 86, p 2

[616] Tina Hunter, Land Access on Private Land for Mineral and Petroleum Activities, A review of existing provisions in Australian states and Territories and selected overseas jurisdictions, February 2017, pg 8

[617] Department of Mines, Industry Regulation and Safety, Private Land Provisions, (accessed 2 January 2018) at < http://www.DMIRS.wa.gov.au/Documents/Minerals/Minerals-Information-brochures-private_land_provisions-4.pdf>

[618] Industry Commission, Mining and Minerals, Processing in Australia, Volume 3: Issues in Detail, Report No.7, 25 February 1991, Ownership of Minerals, Australian Government Publishing Service Canberra, pg 7

[619] *Petroleum and Geothermal Energy Act 2000*, s 9

[620] *Petroleum and Geothermal Energy Act* 2000, s 5

By comparison, land and minerals in the United States are subject to a private ownership framework, unless they are located in federal public lands.[621] The federal government owns thirty per cent of total lands and a large amount of natural gas deposits lies below federal lands.[622] The federal government retains and manages, through federal agencies, most of the land suitable for shale and tight gas exploitation. The Bureau of Land Management (BLM) and the United States Forest Service (USFS), federal agencies, also have a role in regulating shale gas and hydraulic fracturing.

The BLM and USFS provide guidelines which all operations that have been approved under a federal oil and gas lease must follow.[623] The BLM leases minerals and administers oil and gas development activities on over 570 million acres.[624] A further 56 million acres of split estates also exist; where private individuals own surface rights and the federal government owns subsurface rights.[625] The BLM leases federal minerals and administers oil and gas leases, in cooperation with other federal agencies or private surface owners where appropriate.[626] The BLM manages public lands, including the federal mineral estate under a mandate of multiple use as set out in the Federal Land Policy and Management Act of 1976[627] and issues competitive and non-competitive leases.[628]

Outside Federal public lands, a surface landowner's claim to mineral or petroleum title rests at common law on the *cujus est solum* doctrine; that is, whoever owns the soil owns the air above and down to the depths.[629] Some commentators insist that the United States position is 'largely

[621] Samantha Hepburn, 'Does Unconventional Gas Require Unconventional Ownership? An Analysis of the Functionality of Ownership Frameworks for Unconventional Gas Development' (2013) 8:1 *Journal of Environmental and Public Health Law* 1

[622] Stephanie Neitzel, P.E. Esq, Water Quality Regulations for Unconventional Gas Production United States and Australia Comparison, WaterRich Advisors LLC, at < http://www.awa.asn.au/documents/136%20SNeitzel.pdf> (assessed 20 July 2017)

[623] DOI & USDA, Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development: The Gold Book, 2007 at http://blm.gov/pgdata/etc/medialib/blm/wo/MINERALS_REALTY_AND_RESOURCE_PROTECTION_/energy/oil_and_gas.Par.18714.File.dat?OILgas.pdf

[624] Bureau of Land Management, (accessed 13 March 2017) at www.blm.gov

[625] Ibid.

[626] Ibid.

[627] *The Federal Land Policy and Management Act of 1976* (United States) at http://www.blm.gov/flpma/FLPMA.pdf

[628] [AUTHOR?], What is BLM's authority for leasing oil and gas?, (accessed 18 May 2017) at http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/questions_and_answers.html

[629] Bradbrook, A.J, 'The Relevance of the *Cujus est Solum* Doctrine to the Surface Landowner's Claims to Natural resources located above and beneath his Land' (1998) 11 *Adelaide Law Review* 462, 468

a historical accident'.[630] A key principle of the United States land classification system lies in the power of a surface estate owner to sever or 'split' the mineral estate from the surface estate.[631] In the United States, the mineral estate prevails over the surface estate.[632]

A split estate occurs when the 'surface estate and all or part of the mineral estate in a particular parcel are not owned by the same party'.[633] For example, split estate rules apply when the surface is privately held and minerals are publicly held. It also applies where the surface is private and the minerals are private, or where the surface is public and the minerals are private. In Colorado's DJ/Wattenberg Basin, the resources and mineral estate are not publicly held but owned by private entities such as individuals or corporations. In Western Colorado, there is public ownership of minerals and resources.

3.3 Grant of a petroleum resource tenure

3.3.1 Western Australia

In Western Australia, a petroleum operation means 'an operation to explore for petroleum…an operation to drill for petroleum…an operation to recover petroleum…the injection of petroleum [and] any other kind of operation that is prescribed by the regulations not to be a petroleum operation for the purposes of this definition.'[634]

Before operators carry out exploration activities, they must obtain an exploration permit[635] or drilling reservation.[636] An operator must submit an application to DMIRS for approval that is

[630] Kendor P. Jones, John F. (Jeff) Wellborn, Chelsey J. Russell 'Split Estates and Surface Access Issues' *Landman's Legal Handbook*, Chapter 9 (Ricky Mt Min. L. Fdn., 5th ed, 2013)
[631] Samantha Hepburn, 'Does Unconventional Gas Require Unconventional Ownership? An Analysis of the Functionality of Ownership Frameworks for Unconventional Gas Development' (2013) 8:1 *Journal of Environmental and Public Health Law* 22
[632] Catherine Toan, Esq, Split Estates, Colorado Environmental Law Ltd, (accessed 16 June 2017) at http://www.oilandgasbmps.org/docs/GEN324_split%20estates.pdf
[633] Kendor P. Jones, John F. (Jeff) Wellborn, Chelsey J. Russell 'Split Estates and Surface Access Issues' *Landman's Legal Handbook*, Chapter 9 (Ricky Mt Min. L. Fdn., 5th ed, 2013) pg 181
[634] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 5
[635] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 31
[636] Ibid s 29(1)

accompanied by work and expenditure proposals, a summary of the technical qualifications of the applicant (and their employees) and the technical advice and financial resources at their disposal.[637] Operators often carry out exploration activities as a result of acreage releases or under a special prospecting authority.[638] Acreage releases are usually made once or twice a year and are usually announced at industry events.[639] DMIRS releases prospectivity reports for the release areas, data for each release area, application process information, assessment criteria, land access information (native title and environment) and other relevant information.[640]

A special prospecting authority title allows an operator to carry out surveys on the physical or chemical properties of the rocks in the area for a period of six months, but does not allow them to drill wells.[641] If a discovery is not considered economically sustainable, an operator may obtain a retention lease[642] so that if it becomes viable in the future it can be converted to a production licence.[643]

3.3.2 South Australia

All exploration, production and abandonment activities in South Australia are administered by the Department of Premier and Cabinet (DPC) which is the lead regulatory agency in accordance with the PGEA and various other Acts. In South Australia, , 'regulated activity' comprises '…exploration for petroleum or another regulated resource; or operations to establish the nature and extent of a discovery of petroleum or another regulated resource, and to establish the commercial feasibility of production and the appropriate production techniques; or production of petroleum or another regulated substance.'[644]

[637] Ibid s 31(1)(d)(i) to (iv)).
[638] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 105
[639] Department of Mines, Industry Regulation and Safety, Introduction to petroleum acreage, (accessed 5 May 2018) at http://www.dmp.wa.gov.au/Petroleum/Petroleum-acreage-introduction-1585.aspx
[640] Ibid.
[641] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 105
[642] *Petroleum and Geothermal and Energy Resources Act 1967* (WA), s 48A
[643] *Petroleun and Geothermal Energy Resources Act 1967* (WA), s 49
[644] *Petroleum and Geothermal Energy Act 2000* (SA), s 10

An exploration licence authorises an operator to carry out exploration for regulated resources.[645] An exploration licence application must include a proposed work program which includes the cost of operations to be carried out under the program in each year of the licence, a technical report that assesses the prospectivity of the area, and how the proposed work program relates to this prospectivity.[646] Regard must be given to the suitability of an operator's work program in evaluating prospectivity and discovery of regulated resources, the adequacy of their technical and financial resources and the stated criteria for evaluation of the applications.[647] An operator who holds an exploration licence is entitled to the grant of a corresponding retention licence or production licence for a regulated resource discovered in the licence area.[648]

3.3.3 Colorado

Shale and tight gas development on non-federal land is regulated under the OGCA and COGCC rules. The Colorado Oil and Gas Conservation Commission (COGGC) promotes the exploration, development and conservation of Colorado's oil and gas resources and also handles the drilling permit process and ensures operators comply with state based statutes and regulations. Operators must submit several forms to the COGCC before commencing shale and tight gas operations.[649] They must file a *Registration for Oil and Gas Operations* (Form 1)[650], apply for a *Permit to Drill* (Form 2) [651] and submit an *Oil and Gas Location Assessment* (Form 2A) prior to disturbing ground linked to new operations. [652] The permit to drill application must specify the distance between the well and wall or corner of the nearest building, public road, above ground utility, railroad, and property line, include a wellbore diagram, well location plat (the plat shall be a current scaled drawing(s) of the entire section(s)

[645] *Petroleum and Geothermal Energy Act 2000* (SA), s 21(2)
[646] *Petroleum and Geothermal Energy Regulations 2013* (SA), r 6
[647] *Petroleum and Geothermal Energy Act 2000* (SA), s 23
[648] Ibid s 21(3)
[649] Code of Regulations 2 CCR 404-1 at https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=6271&fileName=2%20CCR%20404-1
[650] Rule 302 of COGGC rules at< https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf>
[651] Rule 303 of COGGC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[652] Form 2A of the COGCC rules at https://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/Form2A_20130806.pdf

penetrated by the proposed well with the following minimum information) and deviated drilling plan.[653]

An operator can enter into a voluntary comprehensive drilling plan (CDP).[654] CDP's identify foreseeable gas activities, facilitate discussion about potential impacts and identify measures to minimise adverse impacts to the environment.[655] An operator may ask the Colorado Department of Public Health and Environment and surface owners to participate in compiling a CDP.[656] The COGCC rules contain a number of incentives to encourage operators to develop CDP's.[657] For example, if the CDP contains information similar to what is contained in an oil and gas assessment and the CDP has been subject to the same processes an oil and gas, assessment is not be required.[658]

3.4 Indigenous land and related interests

At various times, operators in Australia have raised concerns about the land access negotiation process, specifically, that when land is subject to a native title claim they feel negotiations can be lengthy and complex and can consist of multiple parties, which in turn can lead to significant delays.[659] In the United States, some industry observers insist that the 'complex history between the federal government and American Indian tribes has created an equally complex division of authority between federal and tribal governments regarding oil and gas development on tribal lands'.[660] In the United States, the ownership of minerals and the affected surface lands is vital in order to determine which regulations apply during a gas operation.[661]

[653] Id at rule 303.
[654] COGCC rules and regulations, definitions (100 Series), Comprehensive Drilling Plan, 100-2
[655] Rule 216(a) of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[656] Rule 216.d.(2) of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[657] Rule 216.f. of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[658] Rule 216.f.(1) of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[659] Minerals and Energy Resource Exploration, Productivity Commission Inquiry Report, No 65, 27 September 2013, p 127
[660] University of Colorado at Boulder, Intermountain Oil and Gas BMP Project, Indian Lands, (accessed 18 June 2017) at < http://www.oilandgasbmps.org/laws/tribal/>
[661] Ibid.

Australia's native title regime and the Indian tribes' regime in the United States add another complex layer to an operator's quest to exploit shale and tight gas. Australia's native title regime enables Indigenous communities to claim their native title rights and interests in the land through the *Native Title Act 1993* (Cth) (NTA). Indigenous groups may be granted exclusive possession of, or limited access to, their traditional lands for many purposes, including hunting, fishing, medicine, accommodation, religion and culture.[662]

3.4.1 Australia

In *Mabo v Queensland (No 2)* ("Mabo case") [1992] HCA 23; (1992) 175 CLR 1, the High Court recognised the rights and interests to land retained under traditional laws and customs and accepted that the Meriam people of the Torres Strait held native title rights and interests over part of their traditional lands.[663] The Mabo decision prompted the Commonwealth Parliament to enact the NTA to provide for the recognition and protection of native title.

These native title rights can include 'the right to possess, occupy, use and enjoy an area to the exclusion of all others (often called the right of exclusive possession).'[664] It includes the right to control access to, and use of, the relevant area, which includes unallocated Crown land, a reserve held for Aboriginal people and pastoral leases held by the native title parties.[665] Native title rights can be 'non-exclusive' rights, i.e. an area is shared by the native title holders and other people. Western Australia's petroleum basins are subject to both exclusive and non-exclusive determined native title rights.[666] Australia's native title claimants have particular rights when titles are granted inside native title claim areas.[667] Native title claimants have the

[662] Minerals and Energy Resource Exploration, Productivity Commission Inquiry Report, No 65, 27 September 2013, p 118
[663] *Mabo v Queensland (No 2)* ("Mabo case") [1992] HCA 23; (1992) 175 CLR 1 (3 June 1992) at http://www.austlii.edu.au/au/cases/cth/HCA/1992/23.html
[664] Department of Mines and Petroleum, Western Australia's Petroleum and Geothermal Explorer's Guide – 2014 Edition, pg 112
[665] Ibid.
[666] Ibid.
[667] National Native Title Tribunal, Negotiation, What is the right to negotiate?, (accessed 23 May 2017) at http://www.nntt.gov.au/futureacts/Pages/Negotiation.aspx

opportunity to provide submissions prior to the grant of a resource title and can negotiate the conditions in which resource titles are granted.[668]

Before an exploration permit is granted operators must abide by the future act provisions of the NTA. A future act is a proposal to deal with land in a way that influences native title rights and interests, for example the granting of a petroleum title.[669] The NTA grants native title claimants rights when titles are granted inside native title claim areas.[670] Native title claimants have a 'right to negotiate'[671] and are notified before a future act is undertaken.[672] They must be given the opportunity to make submissions[673] and negotiate, in good faith, the conditions on which petroleum titles are granted.[674]

Parties that agree can enter into a deed for the grant of petroleum title[675] and/or ancillary agreements that incorporate employment issues, education and training issues and aboriginal heritage protection issues.[676] When parties fail to agree they can apply to the national native title tribunal for a determination.[677] The tribunal can decide that an act must not be done, may be done, or may be done subject to conditions.[678] In *Rusa Resources (Australia) Pty Ltd v Sharon Crowe and Others on behalf of Gnulli* [2015] NNTTA 26, the tribunal determined that the conduct of Rusa did not meet the threshold for good faith.[679] The tribunal was not satisfied

[668] *Native Title Act 1993* (Commonwealth), s 31
[669] *Native Title Act 1993*(Commonwealth), s 29
[670] National Native Title Tribunal, Negotiation, What is the right to negotiate?, (accessed 23 May 2017) at http://www.nntt.gov.au/futureacts/Pages/Negotiation.aspx
[671] Subdivision P – Right to Negotiate of the *Native Title Act 1993* (Cth) at http://www.austlii.edu.au/au/legis/cth/consol_act/nta1993147/
[672] *Native Title Act 1993* (Cth), s 223
[673] *Native Title Act 1993* (Cth), s 31
[674] Department of Mines, Industry Regulation and Safety, Western Australia's Petroleum and Geothermal Explorer's Guide, 2014 Edition, pg 113 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-RES-PUB-100D.pdf
[675] Petroleum Division, Department of Mines and Petroleum, Guidelines for Completion of State Deed (Deed for Grant of Petroleum Title), By Native Title Parties and Grantee Parties, (accessed 19 June 2017) at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PE-PTLA-NT-108D.pdf
[676] National Native Title Tribunal, ILUA or the right to negotiate process? A comparison for mineral tenement applications, 2008, pg 5 at http://www.nntt.gov.au/Information%20Publications/ILUA%20-%20The%20Right%20to%20Negotiate.pdf
[677] *Native Title Act 1993* (Cth), s 35
[678] *Native Title Act 1993* (Cth), s 38
[679] *Rusa Resources (Australia) Pty Ltd v Sharon Crowe and Others on behalf of Gnulli* [2015] NNTTA 26 (16 July 2015)

that Rusa negotiated in the manner required by the tribunal and resolved that they were not empowered to deal with the application and the application was dismissed.[680]

Indigenous Land Use Agreements (ILUAs) are voluntary, legally binding agreements that relate to the use and management of land made between native title parties, operators and governments. An ILUA contains, amongst other things, agreements about a future act or group of future acts, compensation for loss or impairment of native title, the coexistence of native title rights and interests, access, extinguishment of native title, framework agreements and the exercise of native title rights and interests.[681]

The NTA provides for three types of ILUAs, namely, body corporate agreements[682], area agreements[683] and alternative procedure agreements.[684] Where a native title party gives their consent for an act to be carried out, for example, the granting of an exploration licence or licences to an operator in an ILUA, the licence can be granted and other provisions, for example the right to negotiate provisions of the NTA, do not apply.

Operators have obligations under the *Aboriginal Heritage Act 1972* (WA) and *Aboriginal Heritage Act 1988* (SA) respectively. For example, in Western Australia, an operator commits an offence if they excavate, destroy, damage, conceal or in any way alter a site or deal with an object on or under a site.[685] Where an activity has the potential to impact a site, the approval of the Minister must be obtained.[686] This consent specifies that the activity has been approved and sets out where it can be undertaken.[687]

Western Australia's *Aboriginal Affairs Planning Authority Act 1972* (WA) is concerned with reserved lands in Western Australia.[688] The Act sets out that an application for the grant of a

[680] *Native Title Act 1993* (Cth), s 148(a)
[681] National Native Title Tribunal, Steps to an indigenous land use agreement, 2008, pg 7 at http://www.nntt.gov.au/Information%20Publications/Steps%20to%20and%20Indigenous%20Land%20Use%20Agreement.pdf
[682] *Native Title Act 1993* (Cth), s 24BA
[683] *Native Title Act 1993* (Cth), s 24CA
[684] Section 24DA of the *Native Title Act 1993* (Cth), s 24DA
[685] *Aboriginal Heritage Act 1972* (WA), s 17
[686] *Aboriginal Heritage Act 1972* (WA), s 18
[687] Ibid.
[688] *Aboriginal Affairs Planning Authority Act 1972* (WA), Part III

licence or title under the PGERA on reserved land should not be refused without prior consent,[689] or processed without consultation with the Authority,[690] and shall be taken to be approved unless the approval of the Authority, and any terms and conditions to which it may be subject is referred to in the document evidencing the grant.[691] Nothing in the Act affects or is to be taken to detract from the operation of the PGERA.[692] The authority has the power to grant a lease over land whenever vested in the authority under this Act.[693]

South Australia's *Aboriginal Lands Trust Act 2013* (SA) deals with mining operations (including gas operations) on trust land.[694] A mining authority must not be granted or renewed under the PGEA in relation to trust land except to a person who has permission to carry out regulated activities on trust land.[695] Prior to the granting or renewal of a mining authority to engage in a regulated activity under the PGEA, the Minister must allow the trust a reasonable opportunity to make submissions relating to the conditions subject to which the mining authority should be granted or renewed.[696] An operator who has permission to carry out regulated activities on trust land is not required to serve on the trust a notice of entry pursuant to state's gas legislation.[697] An operator who carries out regulated activities without permission, or enters trust land for the purpose of carrying out regulated activities, is guilty of offence.[698]

South Australia's *Anangu Pitjantjatjara Yankunytjatjara Land Rights Act 1981* (SA) grants specific land and other rights to the Anangu Pitjantjatjara Yankunytjatjara people in the states north/north west. The *Maralinga Tjarutja Lands Rights Act 1984* (SA) granted freehold title to about 81 373 square kilometres to the Maralinga Tjarutja people in fee simple. The *Maralinga Tjarutja Lands Rights Act 1984* (SA) caps the compensation amount for exploration disturbance to the lands and the Aboriginal people and their way of life, to a sum no greater than the amount available under the *Mining Act 1971*(SA) and PGEA.

[689] *Aboriginal Affairs Planning Authority Act 1972* (WA), s 30(1)(a)
[690] *Aboriginal Affairs Planning Authority Act 1972* (WA), s 30(1)(b)
[691] *Aboriginal Affairs Planning Authority Act 1972* (WA), s 30(1)(c)
[692] *Aboriginal Affairs Planning Authority Act 1972* (WA), s 30(2)
[693] *Aboriginal Affairs Planning Authority Act 1972* (WA), s 33A
[694] *Aboriginal Lands Trust Act 2013* (SA), s 51(c)
[695] *Aboriginal Lands Trust Act 2013* (SA), s 52(1)
[696] *Aboriginal Lands Trust Act 2013* (SA), s 52(2)
[697] *Petroleum and Geothermal Energy Act 2000* (SA), s 61
[698] *Aboriginal Lands Trust Act 2013* (SA), s 53(1)

3.4.2 The United States

In the United States Indian trust lands and reservations are regulated (along with other legislation) under the Section 397 of the U.S Code which states that:

> Where lands are occupied by Indians who have bought and paid for the same, and which lands are not needed for farming or agricultural purposes, and are not desired for individual allotments, the same may be leased by authority of the council speaking for such Indians, for a period not to exceed five years for grazing, or ten years for mining purposes in such quantities and upon such terms and conditions as the agent in charge of such reservation may recommend, subject to the approval of the Secretary of the Interior.[699]

Indian tribes are estimated to hold three per cent of the known oil and gas reserves and in 2000, the Department of the Interior managed 3772 mineral leases, licenses, permits and applications on more than two million acres of Indian lands.[700] In *United States v Shoshone Tribe of Indians*, 304 U.S. 111 (1938) the Supreme Court determined that that when lands were reserved or set aside for tribes in executive order, treaties or agreements approved by Congress, the tribes held the beneficial rights to the soil and mineral interests under the lands.[701] As a result, on Indian trust lands, tribes retain ownership of the mineral resources, including gas and oil.[702]

Any land impacted by the *Indian General Allotment Act of 1887* (United States) must be examined to determine who holds the mineral title.[703] The intention of the Act was to separate the mineral rights from the tribes by assigning tribal lands to individual members of the tribe which allowed them to sell off lands in fee simple after a certain period of time.[704] The mineral estate was included in the fee simple title, which meant there was an alienation of mineral rights

[699] Section 397, Title 25, Chapter 12 of the U.S Code at https://www.law.cornell.edu/uscode/text/25/397
[700] University of Colorado at Boulder, Intermountain Oil and Gas BMP Project, Indian Land, (accessed 15 June 2017) ay < http://www.oilandgasbmps.org/laws/tribal/>
[701] *United States v Shoshone Tribe of Indians*, 304 U.S. 111 (1938)
[702] Ibid. And see generally University of Colorado at Boulder, Intermountain Oil and Gas BMP Project, Indian Land, [(accessed 15 June 2017) < http://www.oilandgasbmps.org/laws/tribal/>
[703] University of Colorado at Boulder, Intermountain Oil and Gas BMP Project, Indian Land, (15 June 2017) at < http://www.oilandgasbmps.org/laws/tribal/>
[704] *Indian General Allotment Act 1887* (United States) and see generally University of Colorado at Boulder, Intermountain Oil and Gas BMP Project, Indian Land, (accessed 15 June 2017) at < http://www.oilandgasbmps.org/laws/tribal/>

from tribal and tribal member ownership. Often land was sold to non-Indians. The United States congress terminated the General Allotment Act of 1887 in 1934. Since this time, Congress has been working with tribes to re-amalgamate former tribal trust lands. However, many are still impacted by these policies.[705]

The *Leasing and Grazing Act of 1891* (United States) confirmed congressional consent on non-Indian mineral leasing on tribal land and allowed 10 year leases with tribal consent. The *Indian Mineral Leasing Act of 1938* (United States) created a single set of leasing procedures for mineral development on tribal land. This Act was aimed at promoting self-governance by guaranteeing a fair return on tribal minerals.[706] At the federal level, the United States Code states that where land is inhabited by Indians who have purchased it and it is not required for agricultural purposes and not wanted for individual allotments, it may be leased for a period not exceeding five years for mining purposes.[707]

The *Mineral Leasing Act of 1920* (United States) (the MLA) and the *Mineral Leasing Act for Acquired Land of 1947* (United States) contain provisions for private land where mineral rights have been retained by the federal government (split estate lands). The MLA guides the land use planning, leasing, bonding, operations and reclamation associated with all development of federal oil and natural gas resources. The Onshore Order No.1 (2007)[708] also contains surface owner protection provisions. A mineral owner must show due regard for the interests of the surface owner and inhabit only those sections of the surface that are necessary to develop the resource.[709]

Tribal governments in the United States have started to regulate gas development via the enactment of tribal codes, ordinances, constitutions and best management practices.[710] For

[705] University of Colorado at Boulder, Intermountain Oil and Gas BMP Project, Indian Land, (accessed 15 June 2017) at < http://www.oilandgasbmps.org/laws/tribal/>
[706] Ibid.
[707] Section 397, Title 25, Chapter 12 of the United States Code, at https://www.law.cornell.edu/uscode/text/25/397
[708] Onshore Oil and Gas Order, The Order, No.1, Onshore Oil and Gas Operations; Federal and Indian Oil and Gas Leases; Approval of Operations, 2007 at http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/onshore_order_videos.Par.62610.File.dat/Onshore_Order_No_1_The_Order.pdf
[709] Bureau of Land Management, Split Estate, (accessed 18 May 2017) at <http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/split_estate.html>
[710] University of Colorado at Boulder, Indian Law, (accessed 15 June 2017) at http://www.oilandgasbmps.org/laws/tribal/

example, the *Exploration & Production Operator's Manual* provides guidance to operators on how to obtain well drilling authorisations, right of way easements and surface leases.[711] In Colorado, tribal governments have started to regulate gas development via the enactment of tribal codes, ordinances, constitutions and best management practices.[712] The *Exploration & Production Operator's Compliance Manual for Energy Development Projects on the Southern Ute Indian Reservation* regulates operators when they seek to obtain authorisation to drill a gas well, right-of-way easements and surface leases.[713]

The COGCC rules do not apply to Indian trust lands and minerals or the Southern Ute Indian tribe within the exterior boundaries of the Southern Ute Indian reservation.[714] The rules apply to non-Indians conducting gas operations on lands within the exterior boundaries of the Southern Ute Indian reservation where the surface and gas estates are owned by operators other than the Southern Ute Indian Tribe.[715] Indian trust lands and reservations are regulated under the United States Code.[716]

3.5 Environmental approvals and assessment

3.5.1 Western Australia

Operators in Western Australia must submit environment plans (EP) to the DMIRS prior to commencement of operations.[717] EP's are management documents designed to show that all environmental risks and impacts linked with petroleum and/or geothermal activities are

[711] Southern Ute Indian Tribe Growth Fund Department of Energy, The Exploration & Production Operator's Compliance Manual for Energy Development Projects on the Southern Ute Indian Reservation, (15 March 2018) at http://www.suitdoe.com/Documents/EPOperatorsComplianceManual.pdf
[712] University of Colorado at Boulder, Intermountain Oil and Gas BMP Project, Indian Land, (accessed 15 June 2017) at < http://www.oilandgasbmps.org/laws/tribal/>
[713] University of Colorado at Boulder, Southern Ute Tribe Laws, (accessed 15 June 2017) at http://www.oilandgasbmps.org/laws/tribal/southernute.php
[714] Rule 2011 of the COGCC
[715] Oil and Gas, Oil and Gas Pooling, (accessed 12 June 2017) at http://www.oil-gas-leases.com/oil-gas-pooling.html
[716] Section 397, Title 25, Chapter 12 of the United States Code, at https://www.law.cornell.edu/uscode/text/25/397
[717] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) reg 6.

reduced to as low as reasonably practicable and carried out in a way that is consistent with the principles of ecologically sustainable development.[718]

An operator must provide a summary of the approved plan to the Minister for public disclosure.[719] An environmental plan deemed suitable for the nature and scale of the activity will be approved.[720] Plans must establish that the impacts and risks will be reduced to as low as is reasonably practicable and of an acceptable level, provide for appropriate environmental performance objectives, include environmental performance standards and measurement criteria, include an implementation strategy and monitoring, recording and reporting arrangements.[721] An operator must include a description of the activity including its location, construction and layout of gas facilities, operational details, proposed timetables and any additional information relevant to consideration of the environmental impacts and environmental risks of the activity.[722]

EPs must describe the existing environment that may be affected and include details of any specific values and sensitivities.[723] They must include details of impacts and risks, an evaluation of those impacts and risks and a description of the risk assessment process used to evaluate those impacts and risks.[724] An EP must describe the requirements that apply to the activity under legislation, international conventions or agreements, or applicable codes of practice that are relevant to the environmental management of the activity.[725] An operator must provide a copy of their corporate environmental policy, a report on all consultations between themselves and relevant authorities and other relevant persons and organisations in the course of developing the environment plan and a list of all incidents that are classified as reportable incidents in relation to the activity.[726]

[718] Department of Mines, Industry Regulation and Safety, Lodge an Environment Plan, (accessed 20 June 2017) at http://www.dmp.wa.gov.au/Environment/Environment-Plan-6129.aspx
[719] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) reg 11(7).
[720] Id s 11
[721] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 11
[722] Id s 14(1)
[723] Id s 14(2)
[724] Id s 14(3)
[725] Id s 14(6)
[726] Id s 17

The summary plan must include specific information relating to the disclosure of chemicals used in drilling or hydraulic fracturing activities.[727] The summary that is published and available to the public includes details of the proposed activity and environmental considerations, while the complete plan which includes the full risk assessment and implementation strategy is not publicly available and is assessed by the DMIRS internally.[728] The public can access the summary on the DMIRS website.

The EP binds the operators to certain environmental performance objectives, standards and criteria which the operator is assessed against by the DMIRS.[729] If an operator becomes aware of a new or increased risk, they must submit a revised EP to the DMIRS for consideration.[730] The purpose of the plan is to identify systems, practices and procedures that guarantee that environmental impacts and risks are reduced to 'as low as is reasonably practicable'.[731]

If an operation is considered likely to have a significant effect on the environment, it can be referred to the Environmental Protection Authority (EPA) for assessment.[732] The EPA conducts environmental impact assessments on proposals of environmental significance, directed by the test set out in its Environmental Impact Assessment Administrative Procedures 2012.[733] The EPA can determine whether or not to assess referred proposals.[734] The DMIRS refers proposals to the EPA that could, if put into effect, have a significant effect on the environment.[735] The EPA evaluates hydraulic fracturing proposals that it considers likely to have a significant environmental impact.[736] In deciding whether to assess a proposal, the significance of the anticipated environmental impacts, including cumulative impacts, is

[727] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) reg 15(9)
[728] Department of Mines and Petroleum (WA), Summary of Comments and Departmental Responses from Public Consultation for New Environment Regulations: Petroleum and Geothermal Environment Regulations and Guidelines for Preparation and Submission of an Environment Plan (August 2012).
[729] Department of Mines and Petroleum (WA), Guidelines for the Preparation and Submission of an Environment Plan (28 August 2012) 10.
[730] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) reg 8(2).
[731] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) reg 15(3)(a).
[732] *Environmental Protection Act 1986* (WA)
[733] Environmental Protection Authority (WA), Environmental Impact Assessment Administrative Procedures (2012) 5943-5944 at http://www.epa.wa.gov.au/EIA/assessdev/Pages/EIAAdministrativeProcedures.aspx
[734] *Environmental Protection Act 1986* (WA), s 39(a).
[735] Environmental Protection Act 1986 (WA) s 38
[736] Environmental Protection Authority, Hydraulic fracturing for onshore natural gas from shale and tight rocks, Environmental Protection Bulletin No.22, (accessed 17 June 2016) at http://edit.epa.wa.gov.au/EPADocLib/EPB22-Fracking-171214.pdf

considered.[737] The EPA does not approve proposals, although the process it undertakes provides a mechanism where impacts are contemplated.[738]

An assessment may be carried out irrespective of whether a project is in the proof-of-concept stage, e.g. a proof-of-concept proposal involving multiple wells in a location where inadequate environmental information is on hand may be formally assessed.[739] The EPA applies environmental factors and objectives as the foundation for determining whether impacts are tolerable.[740] The EPA considers the impacts associated with hydraulic fracturing proposals consistent with other proposals.[741]

The EPA may consider the 'values, sensitivity and quality of the environment which is likely to be impacted, the extent (intensity, duration, magnitude and geographic footprint) of the likely impacts; consequence of the likely impacts (or change); resilience of the environment to cope with the impacts or change; cumulative impact with other projects; level of confidence in the prediction of impacts and the success of proposed mitigation; objects of the Act, policies, guidelines, procedures and standards against which a proposal can be assessed; presence of strategic planning policy framework; presence of other statutory decision-making processes which regulate the mitigation of the potential effects on the environment to meet the EPA's objectives and principles for EIA; and public concern about the likely effect of the proposal, if implemented, on the environment.'[742]

The DMIRS and the EPA communicate at pre-referral stages in cases where consultation benchmarks are triggered and/or where there is the chance of a significant environmental impact.[743] The onshore criteria include hydraulic fracturing exploration and development

[737] Ibid.
[738] Ibid.
[739] Ibid.
[740] Environmental Protection Authority, Environmental Assessment Guideline No. 8, Environmental Assessment Guideline for Environmental factors and objectives, 2013 at http://www.epa.wa.gov.au/EPADocLib/EAG%208%20Factors%20and%20objectives2013.pdf
[741] Environmental Protection Authority, Hydraulic fracturing for onshore natural gas from shale and tight rocks, Environmental Protection Bulletin No.22, (accessed 17 June 2016) at http://edit.epa.wa.gov.au/EPADocLib/EPB22-Fracking-171214.pdf
[742] Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012
[743] Memorandum of Understanding between the DMIRS and EPA, (accessed 19 June 2017) pg 2 at http://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-016.pdf

activities.[744] The DMIRS and EPA have a Memorandum of Understanding (MOU).[745] The MOU sets out the procedure for communicating before referring a proposal (which includes Programme of Works (exploration), Mining Proposals and EP's to determine if proposals should be formally referred.[746] The EPA have made determinations not to assess referred proposals because they were deemed small proof-of-concept activities and their impacts could be adequately managed by the DMIRS through the implementation of EPs.[747] It is not clearly stated in the MOU that it covers both petroleum and geothermal activities. The DMIRS can refer projects to the Department of Water and Environmental Regulation (DoWER) for water-related advice under an administrative agreement.[748]

The DMIRS also refers projects to the DoWER for water resources advice. The DoWER assesses, issues and controls water licences under the *Rights in Water and Irrigation Act 1914* (WA) (the RiWI Act). The DoWER provides specialist and technical water advice to the DMIRS as part of the DMIRS approvals processes, assists the EPA by the same advice on referrals, provides advice as required to the Appeals Convenor and grants water licences or permits for operators to take water needed for hydraulic fracturing. The approvals processes under the various pieces of legislation require petroleum operators to identify and manage environmental impacts.

3.5.2 South Australia

The PGEA sets a clear role for the public in identifying potential risks of a proposed activity, and the environmental outcomes to be achieved under a Statement of Environmental Objectives (SEO). All activities regulated under the PGEA are also subject to the provisions of the *Natural Resources Management Act 2004* (SA) (NRMA) and the *Environment Protection Act 1993*(SA). Regulated activities must not be carried out unless an approved SEO is in place, prepared on the basis of an Environmental Impact Report (EIR).[749]

[744] Ibid.
[745] Ibid.
[746] Id at 3.
[747] Environmental Protection Authority (WA), Environmental Protection Bulletin No 15 – Hydraulic Fracturing of Gas Reserves (2011) 3.
[748] Department of Water, Water and the shale and tight gas industry, (accessed 15 June 2017) at https://www.water.wa.gov.au/__data/assets/pdf_file/0020/7841/109620.pdf
[749] *Petroleum and Geothermal Energy Act 2000*, s 97

The EIR describes the detailed characteristics of the environment where the activities will take place and identifies potential impacts, risks and the proposed risk-mitigation strategies. The SEO sets out the environmental objectives to be achieved to address the risks identified in the EIR and the criteria to be used to assess achievement of the objectives. The EIR and SEO are expected to deal with, amongst other things, impacts on aquifers, including pressure and contamination, impacts on groundwater use, contamination of surface water and shallow groundwater, water storage ponds, flow-back storage ponds, disturbance to existing land uses and remediation and rehabilitation requirements.[750]

An SEO must be prepared for low impact or medium impact activities on the basis of an EIR and for high impact activities on the basis of an EIA.[751] An operator must set out project objectives, the criteria that will be applied to determine whether the objectives have been achieved, compliance requirements and reporting obligations.[752] An SEO must set out how land adversely affected by regulated activities will be rehabilitated.[753] For high impact activities, an operator must provide a report or periodic reports from an independent expert on the environmental consequences of the activities; and may include a system for evaluating the licensee's environmental performance.[754]

The PGEA contains very distinct consultation requirements. Stakeholders, including landholders, must be informed and advised on the potential risks associated with proposed activities, and the management strategies that will be used to minimise risk. They must be provided with the opportunity to raise any issues of concern before regulated activities commence. The DPC (SA) anticipates that licensee's will initiate consultation with stakeholders prior to and during the development of their EIR and SEO, to describe their activities and the potential impacts which may be experienced.

The PGEA has a much more robust environmental management regime than the PGERA. Although a Western Australian operator must describe the activities they intend to undertake and provide information about environmental impacts and risks in terms of the existing environment and a risk assessment process used to evaluate those impacts and risks, this

[750] *Petroleum and Geothermal Energy Regulations 2013* (SA)
[751] *Petroleum and Geothermal Energy Act 2000*, s 99
[752] Id s 100
[753] Id s 100(2)
[754] Id s 100(3)

information is only provided prior to the activities being carried out and does not include any detail about post activity. In setting out how land adversely affected by regulated activities will be rehabilitated, an SEO goes far beyond what is needed in an environmental plan.

SEOs explicitly address impacts on aquifers, impacts on groundwater use, contamination of surface water and shallow groundwater, water storage ponds and flow-back storage ponds. Environmental plans do not cover this to the same extent. An object of the PGEA is to establish appropriate consultative processes involving people directly affected by regulated activities and the public generally. The PGERA is silent on consultative processes. The DMIRS (WA) and DPC (SA) should encourage operators to submit some form of voluntary CDP similar to that which exists in Colorado. It has been suggested that, though they are voluntary, CDPs would be more effective if operators developed joint CDPs to cover the activities of multiple operators[755] Western Australia and South Australia lag behind Colorado in terms of facilitating discussion with stakeholders around potential impacts and harm minimisation measures.

During exploration in South Australia, the EPA (SA) provides advice to DPC (SA). The EPA (SA) regulates off site activities linked to exploration under the *Environment Protection Act 1993* (SA), for example the transport of waste and disposal requirements. The *Environment Protection Act 1993* (SA) applies to operators undertaking petroleum production activities. The EPA (SA) works with DPC to provide advice through their SEO and EIR process. The EPA (SA) is a mandatory referral agency under the *Petroleum and Geothermal Energy Regulations 2000* (SA). Where exploration activity is referred to the EPA (SA) for assessment and comment, the EPA (SA) considers whether the proposed risk ranking is appropriate, and advises DPC (SA) accordingly. Above certain thresholds[756], a licence from the EPA (SA) is required to undertake activities. The EPA (SA) and DPC (SA) both have a role in the production phase, and therefore have an Administrative Arrangement (AA) and a Memorandum of Understanding (MOU).[757] The AA sets out the responsibilities of each agency, and identifies which agency takes the lead on potential environmental incidents.

[755] Keith N. Eshleman & Andrew Elmore, Recommended Best Management Practices for Marcellus Shale Gas Development in Maryland, 2013, University of Maryland Center for Environmental Science
[756] Environmental Protection Act 1993 (SA, Schedule 1
[757] Administrative Arrangements (accessed 17 May 2018) < http://minerals.statedevelopment.sa.gov.au/mining/mining_regulation_in_south_australia/administrative_arrangements>

South Australia's Department of Environment, Water and Natural Resources (DEWNR) is a referral agency under the PGEA and is provided with SEOs for comment and advice on a range of matters, including water issues related to petroleum production. The NRMA provides the statutory framework requiring the sustainable and integrated management of water. Water resources that are highly valued are prescribed to protect their integrity and ensure proper management and sustainable use. Prescribed water resource areas are managed through a water allocation plan (WAP) that sets the limit on the volume of water that can be taken and used. A water licence is required to take water from a prescribed area, under the conditions set in the relevant WAP.

3.5.3 Colorado

The COGCC consults with the Department of Public Health and Environment (CDPHE) when it receives an Application for Permit-to-Drill[758], Oil and Gas Location Assessment[759] where a local government requests CDPHE participation in COGCC's consideration[760] or where an operator seeks an adjustment from, or consultation in relation to, for example, public water system protection[761] and underground disposal of water.[762] The CDPHE may suggest monitoring requirements or best management practices.[763] They may also recommend whether a variance request should be granted.[764]

[758] Rule 303(a)(1) of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[759] Rule 303.b of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[760] Rule 306.d.(1)(A)(i) of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[761] Rule 317B of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[762] Rule 325 of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[763] Rule 306(3)(A) of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf
[764] Rule 306(3)(A) of the COGCC rules at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules.pdf

3.6 Regulatory approaches

There are a number of regulatory approaches suited to the exploitation of shale and tight gas that are situated somewhere between strict forms of regulation and de-regulation.[765] Up until the 1990s, command and control regulation and prescriptive approaches, both strict forms of regulation, were the standard regulatory approaches used to manage the exploitation of unconventional gas.[766] Both have been effective in dealing with environmental issues.[767]

Western Australia's approach to exploiting shale and tight gas is risk based and objective based.[768] South Australia's approach is also risk and objective based.[769] Colorado mainly uses command and control and case by case permitting to regulate the exploitation of shale and tight gas.[770] As far as the DMIRS is concerned, command control type approaches, which are largely prescriptive approaches, tend to become outdated and counterproductive.[771]

Although Western Australia's approach to regulation is risk/objective based, it does take a prescriptive approach to data submission and reporting.[772] Some argue that there is no ideal regulatory model.[773] While this is probably correct as long as approaches are low cost, low risk and they decrease health, safety and environmental risks and protects other public interests,

[765] Rob White & Diana Heckenberg, Legislation, Regulatory Models and Approaches to Compliance and Enforcement, Briefing Paper No.6, July 2012, pg 12

[766] Olmstead, Sheila and Nathan Richardson, Managing the Risks of Shale Gas Development Using Innovative Legal and Regulatory Approaches, Discussion Paper, Resources for the Future, June 2014, page 8 at http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-14-15.pdf

[767] N. Gunningham & D. Sinclair, *Leaders and Laggards: Next Generation Environmental Regulation* (Sheffield: Greenleaf Publishing, 2002).

[768] Department of Mines and Petroleum, Guidelines for the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* and *Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015*, pg 5

[769] Natural Resource Committee, Inquiry into unconventional gas fracking, Submission from the South Australian Government, January 2015, pg 29 http://minerals.statedevelopment.sa.gov.au/_data/assets/pdf_file/0009/263457/Inquiry_into_Unconventional_Gas_Fracking_S-_SA_Government_Submission.pdf

[770] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, and Hannah Wiseman, The State of State Shale Gas Regulation: Appendices, June 2013, Resource for the Future, pg 21 http://www.rff.org/files/document/file/RFF-Rpt_StateofStareRegs_Appendices_0.pdf

[771] Department of Mines and Petroleum, Guidelines for the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* and *Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015*, pg 5

[772] For example Part 8 of the *Petroleum and Geothermal Energy Resources (Resources Management and Administration) Regulations 2015* (WA)

[773] Alan Hardacre, 'Better Regulation – What is at Stake?' (Training Paper, European Institute of Public Administration, 2008) 3 at http://www.eipa.eu/files/repository/eipascope/20080905132115_SCOPE2008-2_1_AlanHardacre.pdf

they are likely to be effective.[774] The unique social, political and geologic differences between jurisdictions is not enough to justify some jurisdictions regulating more or less rigorously or indeed, not regulating some elements at all.[775]

According to some industry commentators substantial overlap exists i.e., states may choose to use a hybrid approach, with more than one regulatory tool for an element. For example, states in the United States frequently use a command and control regulation to set state-wide minimum standards but require case-by-case permit review or allow exceptions or variances from the state wide standard upon application and approval.[776] In these cases, command and control was considered the primary form of regulation.[777]

3.6.1 Western Australia and South Australia – objective/risk based

Most industry commentators consider risk and objective based approaches best practice for modern regulation.[778] Western Australia's objective based approach sits within a risk management framework.[779] The move towards an objective based approach for Western Australia was a deliberate move away from the previous prescriptive regime contained in the 'Schedule of Onshore Petroleum Exploration and Production Requirements -1991 (amended 21 May 2010)' and 'Schedule of Geothermal Exploration and Production Requirements 2009'.[780]

[774] Ibid.

[775] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, and Hannah Wiseman, The State of State Shale Gas Regulation, Executive Summary, May 2013, pg 5

[776] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, and Hannah Wiseman, 'The State of State Shale Gas Regulation', June 2013, pg 14 at http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-StateofStateRegs_Report.pdf

[777] Ibid

[778] Natural Resources Committee, Parliament of South Australia, Inquiry into unconventional gas fracking, Submission for the South Australia Government, Department of State Development, January 2015, pg 29 at < http://minerals.statedevelopment.sa.gov.au/__data/assets/pdf_file/0009/263457/Inquiry_into_Unconventional_Gas_Fracking_-_SA_Government_Submission.pdf>

[779] Department of Mines, Industry Regulation and Safety, Guidelines to Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015, September 2016, pg 4

[780] 'Schedule of Onshore Petroleum Exploration and Production Requirements – 1991 (WA) (Amended 21 May 2010)'; 'Schedule of Geothermal Exploration and Production Requirements 2009 (WA)

The objective and risk based approaches taken in Western Australia and South Australia are based on the belief that responsibility for achieving objectives and managing risk, through the use of industry 'best practice', rests with operators.[781] These approaches require operators to achieve regulatory objectives and manage risks by broadly replicating industry 'best practice'.[782]

South Australia also uses a risk and objective based approach to exploiting shale and tight gas.[783] The focus in South Australia is on achieving environmental outcomes (on what should be achieved not how), obligations to achieve objectives rather than it being the responsibility of regulators. The DPC encourages operators to invent new technologies and ensures there is 'fit for purpose' regulation. Stakeholder input is incorporated in setting outcomes and assessing the ability of operators to achieve outcomes.[784]

An objective based approach requires operators to meet legislative objectives through self-determination i.e., it is their responsibility to advise regulators on how they plan to achieve the objectives.[785] The approach establishes key principles and objectives in legislation and sanctions judgement, i.e. operators are allowed to put into effect principles and objectives in an appropriate way.[786] Operators must use appropriate standards to demonstrate to how objectives are to be achieved within an acceptable risk profile.[787] Some insist that an objective

[781] Department of Mines, Industry Regulation and Safety, Guidelines for the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015*, pg 5 at http://www.DMIRS.wa.gov.au/documents/PD-SBD-ADM-180D.pdf

[782] Department of Mines, Industry Regulation and Safety, Guidelines to Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015, September 2016, pg 4

[783] Natural Resources Committee, Parliament of South Australia, Inquiry into unconventional gas fracking, Submission for the SA Government, Department of State Development, January 2015, pg 29 at < http://minerals.statedevelopment.sa.gov.au/__data/assets/pdf_file/0009/263457/Inquiry_into_Unconventional_Gas_Fracking_-_SA_Government_Submission.pdf>

[784] Ibid.

[785] Department of Mines, Industry Regulation and Safety, Guidelines for the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015, pg 5 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-ADM-180D.pdf

[786] Taskforce on Reducing Regulatory Burdens on Business, 2006, pg 160, at <http://www.pc.gov.au/research/supporting/regulation-taskforce/report/regulation-taskforce2.pdf>

[787] Department of Mines, Industry Regulation and Safety, Guidelines for the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015*, pg 5 at http://www.DMIRS.wa.gov.au/documents/PD-SBD-ADM-180D.pdf

based approach is particularly useful in complex or rapidly developing industries and the approach suits shale and tight gas production.[788]

Risk has become a popular regulatory tool.[789] Those that support a risk based approach insist that it aids governance by 'contributing to efficient and effective use of regulatory resources and delivering interventions in proportion to risk'.[790] Those who oppose it insist that its implementation challenges diminish its potential.[791] Risk is about studying 'the causes of disaster and failure'.[792] Some insist that risk implies that there is the 'anticipation of catastrophe'.[793] Risk based frameworks seek to control risks rather than ensuring compliance with specific rules.[794] A risk based approach focuses on risk management and risk reduction to levels that society considers acceptable.[795] The approach encourages development by offering incentives.[796] This approach requires operators to identify and moderate risks based on likelihood and outcomes.[797] The process demands that judgements are made on a number of matters, especially on how risks are 'bundled'.[798]

A key element of a risk-based approach is risk assessments that provides a risk rating. Those activities which pose the greatest risk are often targeted with the added inspection and enforcement regimes.[799] Risk assessments are carried out during exploration, production and

[788] Simon Robb, 'A best practice regulatory proposal for shale gas production', Doctor of Juridical Science thesis, The University of Western Australia, 2014, pg 79

[789] Rothstein H, Huber M, Gaskell G., 'A theory of risk colonisation: the spiralling regulatory logics of societal and institutional risk' (2006) 35(1) *Economy and Society* 91 -112

[790] Henry Rothstein, Phil Irving, Terry Walden and Roger Yearsley, 'The risks of risk-based regulation: Insights from the environmental policy domain' (2006) 32 *Environmental International* 1056, 1056

[791] Ibid.

[792] Robert Baldwin, Martin Cave & Martin Lodge, *Understanding Regulation, Theory, Strategy, and Practice* (Oxford, 2nd Edition, 2012) pg 85

[793] U. Beck, 'Living in the World Risk Society' (2006) 35(3) *Economy and Society* 329-45

[794] Robert Baldwin, Martin Cave & Martin Lodge, *Understanding Regulation, Theory, Strategy, and Practice* (Oxford, 2nd Edition, 2012) pg 281

[795] Andreas Klinke and Ortwin Renn, 'A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based,and Discourse-Based Strategies' (2002) 22 *Risk Analysis* 1071.

[796] H Rothstein et al, 'The Risks of Risk-Based Regulation: Insights from the Environmental Policy Domain' (2006) 32 *Environment International* 1056, 1056-1061.

[797] Tania Murray, Dr Edward Andre and Krishna Prasad, 'Holding fracking operations to account for environmental contamination in risk-based regulatory regimes: Insights from the United States' (2016) 33 *EPLJ* 222, 228

[798] Robert Baldwin, Martin Cave & Martin Lodge, *Understanding Regulation, Theory, Strategy, and Practice* (Oxford, 2nd Edition, 2012) pg 283

[799] Simon Robb, 'A best practice regulatory proposal for shale gas production', Doctor of Juridical Science thesis, 2014, pg 76

abandonment.[800] Some insist that 'regulators do not know where the next big failure will come from, but they must act as if they do'.[801] In doing so, they have to decide whether to err on the side of doing something now that does not need to be done, 'because it turns out later on that it should have done'.[802] A risk-based approach allocates resources according to societal risks 'considering both the impacts themselves and the likelihood that they happen, in order to establish appropriate levels of control.'[803]

A risk-based approach provides flexibility and allow for continuous improvement in response to new scientific, technological advances and social considerations.[804] In using a risk-based approach, regulators recognise that it may be more cost-effective to allow some techniques to fail as long as the consequence or likelihood of failure is appropriately low.[805] A risk-based approach can 'contribute to regulatory efficiency' and 'help provide a defensible rationale for decision-making'.[806] Purported failings can be addressed by the use of checklists to ensure issues are 'identified and weighted, consistent with openly available criteria and used in decision-making'.[807]

A risk-based approach to developing regulations follows on from an evaluation of hazards and risks that influence evolving regulatory frameworks.[808] This guarantees that the activities that present the biggest risk are monitored with a combination of 'direct' government monitoring, accompanied by reviewing operators' reports.[809] For example, the conditions attached to an

[800] Responsible Shale Development, Enhancing the Knowledge Base on Shale Oil and Gas in Canada, Energy and Mines Minister's Conference, Yellowknife, Northwest Territories, August 2013, pg 25 at https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/www/pdf/publications/emmc/Shale_Resources_e.pdf

[801] Julia Black, *The Emergence of Risk-Based Regulation and the New Public Risk Management in the United Kingdom* (P.L. Autumn © Sweet & Maxwell and Contributors,2005) pg 546

[802] Ibid.

[803] Henry Rothstein, Phil Irving, Terry Walden and Roger Yearsley, 'The risks of risk-based regulation: Insights from the environmental policy domain' (2006) 32 *Environmental International* 1056, 1057

[804] McFadyen, D. *Regulatory Actions and Issues Energy Resources Conservation Board* (ERCB) Presentation to the Interstate Oil and Gas Compact Commission (Alberta)(June, 2011).

[805]DNV, Risk Management of Shale Development and Operations, DNV, (January 2013) , pg 8 at http://www.igu.org/sites/default/files/DNV%20GL%20Report-%20Risk%20Management-Shale%20gas_0.pdf

[806] Henry Rothstein, Phil Irving, Terry Walden and Roger Yearsley, 'The risks of risk-based regulation: Insights from the environmental policy domain' (2006) 32 *Environmental International* 1056, 1061

[807] Simon Robb, 'A best practice regulatory proposal for shale gas production', 2014, pg 78,

[808] Responsible Shale Development Enhancing the Knowledge Base on Shale Oil and Gas in Canada, Energy and Mines Ministers' Conference Yellowknife, Northwest Territories August 2013, pg 29 at https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/www/pdf/publications/emmc/Shale_Resources_e.pdf

[809] Department of Energy & Climate Change, About shale gas and hydraulic fracturing (fracking), 2013, pg 21 at

operator's environmental licences specify the minimum conditions for site based monitoring and reporting.[810] There are situations where prescriptive requirements, or rules, are required, or where prescription will reduce regulatory burdens by providing operators with a well-defined focus about what they are required to do to simplify and standardise there administrative processes.[811]

Some industry commentators argue that regulatory frameworks should be reinforced by two main pillars: risk-based approach and play-based approach – the risk-based approach provides a flexible approach to account for the variability of unconventional gas reservoirs, while the play-based approach provides a science based approach to organizing the risks of development around a play (such as, geology, location, reservoir properties).[812]

3.6.2 Colorado – command & control and case by case permitting

In the United States, a great deal of federal and state environmental law strongly fits the command and control regulatory approach.[813] In 2013, Resources for Future published a report titled, 'The State of State Shale Gas Regulation'.[814] The report surveyed twenty five elements of the shale gas exploitation process in 31 states.[815] The authors note that the 'review

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/268017/About_shale_gas_and_hydraulic_fracturing_Dec_2013.pdf

[810] Department of Energy & Climate Change, About shale gas and hydraulic fracturing (fracking), 2013, pg 21 at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/268017/About_shale_gas_and_hydraulic_fracturing_Dec_2013.pdf

[811] Department of Mines, Industry Regulation and Safety, Guidelines for the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* and *Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015*, pg 5 at <http://www.DMIRS.wa.gov.au/documents/PD-SBD-ADM-180D.pdf>

[812] McFadyen, D. *Regulatory Actions and Issues Energy Resources Conservation Board* (ERCB) Presentation to the Interstate Oil and Gas Compact Commission (Alberta)(June, 2011).

[813] David A Dana & Hannah J. Wiseman, 'A Market Approach to Regulating the Energy Revolution: Assurance Bonds, Insurance, and the Certain and Uncertain Risks of Hydraulic Fracturing' (2015) 99 *Iowa Law Review* 1523, 1547

[814] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, & Hannah Wiseman, The State of State Shale Gas Regulation, June 2013, pg 8 at http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-StateofStateRegs_Report.pdf

[815] Ibid.

is broad but necessarily incomplete – fully describing even one state's shale gas-related regulations would probably take multiple volumes and would need to be updated frequently'.[816]

The authors selected and reviewed general well spacing, building setback, water setback, pre-drilling water well testing, casing/cementing depth, cement type production, surface, intermediate and production casing cement circulation, water withdrawals, fracking fluid disclosure, fluid storage options, freeboard, pit liners, underground injection, fluid disposal options, wastewater transport tracking, venting, flaring, severance taxes, well idle time limits, temporary abandonment, accident reporting, bans and moratoria and regulatory agencies.[817]

The 'elements in the analysis were selected to give an overview of common regulations throughout the shale gas development process and are sufficient…to give an accurate general picture of the state of state regulation…our data do not include federal, local, or, for the most part, state level regulation that does not apply state-wide (i.e., field-specific rules)'.[818]

Of the 20 elements examined in Colorado, command and control was used to administer 18.[819] For example, command and control is used to administer pre-drilling water well testing, water withdrawal restrictions, setback restrictions from buildings, setback restrictions from water sources, casing and cementing depth requirements, surface, intermediate and production casing cement circulation regulations, venting and flaring regulations, fracking fluid disclosure regulations, underground fluid injection and temporary abandonment.[820] A permit was needed to administer one element (water withdrawal restrictions) and no evidence of regulation was found in one case (cement type regulations).[821]

Command and control regulation comprises highly prescriptive rules requiring regulatory bodies to do specific things without regard to special circumstances, economic conditions, and the like.[822] It is characterised by legislation and the development of rules ('or commands')

[816] Id at 1.
[817] Id at 9.
[818] Id at 8.
[819] Id at 21.
[820] Ibid.
[821] Ibid.
[822] Id at 5.

administered by regulatory bodies acting under legislative authority.[823] Rules are specific and operators are required to comply with them.[824] Activities are managed through the identification of potential risks and a determination of how operators will control them.[825] Command and control regulation is accompanied by the ability of regulators to fine operators if they fail to comply with rules, order operators to comply and terminate their operations.[826]

A command and control approach to regulation involves the utilisation of 'best practices' to reduce external harms.[827] Operators are required to implement 'state of the art' practices i.e., practices that are more rigorous (technically advanced and economically viable) than common practices.[828] This type of regulation is based on the premise that 'if some producers can operate profitably whilst providing certain harm-preventing measures, all producers should be required to do so'.[829] Although command and control regulation provides less protection than banning activities outright, it does provide reassurance to the public.[830]

Some industry commentators insist that the problem with command and control regulation is the sanctioning of inefficient rules that are developed with regard to current technology rather than rigorous assessment of costs and benefits.[831] A command and control approach to regulation often results in over-regulation, a burden, or in under-regulation, an excessive

[823] David A Dana & Hannah J. Wiseman, 'A Market Approach to Regulating the Energy Revolution: Assurance Bonds, Insurance, and the Certain and Uncertain Risks of Hydraulic Fracturing' (2015) 99 *Iowa Law Review* 1523, 1547

[824] Ibid.

[825] Simon Robb, A Best Practice Regulatory Proposal for Shale Gas Production, Doctor of Juridical Science thesis, The University of Western Australia, 2013, pg 73

[826] David A Dana & Hannah J. Wiseman, 'A Market Approach to Regulating the Energy Revolution: Assurance Bonds, Insurance, and the Certain and Uncertain Risks of Hydraulic Fracturing' (2015) 99 *Iowa Law Review* 1523, 1547

[827] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 206

[828] Restatement (Third) of Torts: Products Liability § 2, cmt. d. (1996) Cornell Journal of Law and Public Policy, Volume 5, Issue 2, *Winter*, See, e.g., *The T.J. Hooper*, 60 F.2d 737 (2d Cir. 1932) (holding that it was negligent for coastal tug to operate without a radio receiver given that some tug boat operators in the industry provided radio receivers for their vessels).

[829] For water pollution, these are called "effluent standards." 33 United States.C. § 1314(b) (2006). Effluent standards, like best practices regulations, are generally set using existing technology as the relevant benchmark. Once the relevant range of standards is identified based on existing technology, however, it is possible to use cost-benefit analysis in selecting among appropriate technological benchmarks. See, e.g., Entergy Corp. v. Riverkeeper, Inc., 556 United States. 208, 226 (2009).

[830] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 206

[831] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 207

risk.[832] Command and control can discourage innovation by restricting best practices at a point in time.[833] Some industry commentators argue that operators are likely to prefer command and control regulation as it provides reasonably foreseeable regulatory costs.[834]

Command and control is ideal for the early stages of regulatory intervention.[835] Some industry commentators insist that using a command and control approach can, to some extent, alleviate the concerns of those vehemently opposed to an activity.[836] This approach allows regulators to set clear limits and to administer them within a legislative framework.[837] It has been suggested that command and control regulation, once implemented, can lead to community disengagement and increased industry distrust.[838]. Furthermore, some suggest that command and control has the tendency to encourage a system that requires the need for excessive conformity, where 'layer upon layer' of strict rules impact unreasonably upon operators, inhibiting managerial innovation and decision making.[839]

Prescriptive requirements, or rules, provide operators with a clear understanding of what they must do, thus streamlining and regulating administrative processes.[840] Western Australia has a degree of prescriptive regulation for the content and layout requirements for various approval applications, reports and data.[841] The purpose is to provide a 'checklist' which covers topics that an operator must consider in the provision of information for a submission.[842] Some insist that there needs to be a balance between prescriptive regulation and performance based

[832] See, e.g., Bruce A. Ackerman & Richard B. Stewart, 'Reforming Environmental Law' (1985) 37 *Stan. L. Rev.* 1333, 1335–37

[833] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 207

[834] Ibid.

[835] Robert Baldwin and Martin Cave, *Understanding Regulation – Theory, Strategy and Practice* (Oxford Press, 1999), 35

[836] Ibid.

[837] Ibid.

[838] Simon Robb, 'A best practice regulatory proposal for shale gas production', 2014, pg 75 at

[839] Ibid.

[840] Department of Mines, Industry Regulation and Safety, Guidelines for the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* and *Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015*, pg 5 at http://www.DMIRS.wa.gov.au/documents/PD-SBD-ADM-180D.pdf

[841] For example, Part 8 of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 (WA)

[842] Department of Mines, Industry Regulation and Safety, Guidelines for the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* and *Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015*, pg 5 at <http://www.DMIRS.wa.gov.au/documents/PD-SBD-ADM-180D.pdf>

regulation (objective based) to guarantee high standards while encouraging innovation and technological improvement.[843] Performance based standards enable operators to be flexible.[844]

The move from prescriptive regulation to other types of regulation is the result of the suggestion that, given the unconventional gas sector is subject to rapid technological change, prescriptive regulations are prone to becoming redundant and counterproductive in their intended role.[845] There is also recognition that in circumstances where governments attempt to prescribe through legislation appropriate measures to minimise risk, governments assume a role in risk minimisation.[846]

Case by case permitting involves formal processes and regulatory review.[847] Decision making rests entirely with regulators and allows variable risks to be addressed.[848] The goal is to prevent operators from avoiding regulation through technical compliance only; i.e., they comply with regulations technically but not with the spirit of them.[849] Case-by-case permitting affords operators great flexibility but also requires the greatest regulatory resources.[850] The approach is considered administratively costly given permits are reviewed, though some insist that they may not be uniformly enforced.[851] It is suggested that case-by-case permitting lacks transparency given it is hard and often impossible to know in advance what is necessary for permit approval, or for 'onlookers' to gauge regulatory requirements and stringency.[852] There

[843] World Energy Outlook, Golden Rules for a Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, 2011, pg 47 at http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf

[844] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, & Hannah Wiseman, The State of State Shale Gas Regulation, Executive Summary, May 2013, pg 5

[845] Department of Mines and Petroleum, Guidelines to Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015 (September 2016), pg 4 at http://www.dmp.wa.gov.au/Documents/Petroleum/PD-SBD-ADM-180D.pdf

[846] Ibid.

[847] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, & Hannah Wiseman, 'The State of State Shale Gas Regulation', June 2013, pg 14 at http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-StateofStateRegs_Report.pdf

[848] Hannah Wiseman, Evaluating and Enhancing the Capacity of the States to Govern Unconventional Oil and Gas Development Risks, (2014) at http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_084382.pdf

[849] Nathan Richardson, Madeline Gottlieb, Alan Krupnick, & Hannah Wiseman, 'The State of State Shale Gas Regulation', June 2013, pg 14 at < http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-StateofStateRegs_Report.pdf>

[850] Id at 15.

[851] Id at 14.

[852] Ibid.

is little evidence to suggest that case-by-case permitting is less strict or less effective than the command-and-control approach or performance standards.[853]

3.6.3 Other regulatory approaches

Self-regulation sees operators develop and self-enforce rules which have been agreed to by a collective membership for the purpose of mutual benefit.[854] Some insist that self-regulation should be adopted to avoid the burden of government regulatory interference or maintain standards or reputation.[855] It is suggested that self-regulation might fill gaps in regulatory agendas and even promote advanced levels of environmental responsibility and governance.[856] In order to achieve self-regulation, industries need to manage the process, that is, find solutions to problems, whether actual of perceived, in the absence of oversight from government (or regulatory bodies).[857]

Self-regulation allows operators to make decisions to prevent environmental impacts, to monitor shale and tight gas production sites, and determine how to protect the public.[858] Some argue that self-regulation is ineffective and does little to establish a social licence to operate.[859] The shortcoming of self-regulation to manage shale and tight gas production are magnified by the unanswered questions about the treatment of hydraulic fracturing waste water, chemical use and the liability for abandoned wells.[860]

[853] Id at 8.
[854] Simon Robb, 'A best practice regulatory proposal for shale gas production', 2014, pg 70
[855] R S Khemani and DM Shapiro, 'Glossary of Industrial Organisation Economics and Competition Law' (Glossary, Organisation for Economic Co-Operation and Development, 1993) 73 at <http://www.oecd.org/regreform/sectors/2376087.pdf>
[856] Jennifer Nash, Assessing the Potential for Self-Regulation in the Shale Gas Industry, Harvard Kennedy School, (accessed 16 April 2017) at http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_084362.pdf
[857] Jillian Segal, Institutional self-regulation: what should be the role of the regulator?, (accessed 12 June 2017) at http://download.asic.gov.au/media/1341128/NIGConf_081101.pdf
[858] Matt Mace, Fracking Business as Usual, Analysis of the Failing EC Recommendations on Shale Gas, 2015, pg 5 at <https://www.scribd.com/doc/284048822/Fracking-Business>
[859] Id at 43.
[860] Ibid.

Adaptive Management (AM) supports the communities' perception of ecosystems and the concerns they have with the environment.[861] It involves managing plans, monitoring and evaluating results and making adjustments according to what is learned.[862] AM is based on the idea that nature is dynamic and variable.[863] As a result, it is difficult to predict the effect a shale and tight gas project or regulatory regime will have on the environment before it is applied.[864]

For AM to effectively inform complex environmental policy and decision-making, stakeholders must 'have the authority, means, and capacity to monitor and evaluate the effectiveness of management and regulatory options once they are chosen… and they must have a willingness and mechanism for adapting and revising options in the face of new information'.[865] Some commentators have suggested that AM is well suited to the challenges associated with shale and tight gas production given decisions are made in the context of 'significant uncertainty, limited scientific experience, and conflicting agendas of multiple stakeholders'.[866] The impacts of shale and tight gas extraction are minimised by applying 'good regulation and adaptive management'.[867] AM is based on agreement i.e., agreement as to risks that should be incorporated using regulatory regimes.[868]

AM is reinforced by a preparedness to investigate regulatory options, the capacity to monitor and evaluate the regulatory options once they are chosen, and a willingness to adapt regulatory

[861] Jessica Lee, Theory to practice: Adaptive management of the groundwater impacts of Australian mining projects, (2014) 31 *EPLJ* 251, 252

[862] Williams B, "Adaptive Management of Natural Resources: Framework and Issues" (2011) 92 *Journal of Environmental Management* 1346, 1347; Reever Morghan K, Sheley R and Svejcar T, 'Successful Adaptive Management: The Integration of Research and Management' (2006) 59(2) *Rangeland Ecology & Management* 216, 216-217; Gregory R, Ohlson D and Arvai J, 'Deconstructing Adaptive Management: Criteria for Applications to Environmental Management' (2006) 16(6) *Ecological Applications* 2411, 2412.

[863] Jessica Lee, 'Theory to practice: Adaptive management of the groundwater impacts of Australian mining projects' (2014) 31 *EPLJ* 251, 252

[864] Thrower J, 'Adaptive Management and NEPA: How a Nonequilibrium View of Ecosystems Mandates Flexible Regulation' (2006) 33 *Ecology Law Quarterly* 871, 873.

[865] Brian G. Rahm & Susan J. Riha 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci.: Processes Impacts* 1400, 1408 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H

[866] *Adaptive Environmental Impact Assessment and Management*, ed. C. Holling, John Wiley, London, 1978

[867] Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, Australian National University, July 2012, page 35 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF

[868] Ibid.

regimes when new information is presented.[869] AM is a coordinated, continual decision-making process that can be used to deal with the environmental management challenges of shale and tight gas operations given that decisions are made in circumstances where there is significant uncertainty, reinforced by a limited scientific understanding of the impacts, and divergent stakeholder views.[870]

AM involves the collection of baseline data and constant monitoring, to ensure that impacts are detected and suitable action taken.[871] Regulatory responses to potential risks ought to be based on the possibility of risk, and where there is limited evidence to assess the possibility of risk, adaptive management is a suitable approach.[872] In terms of the water management, short and long term is planning is paramount. AM involves monitoring, accounting and reporting of water extraction, which informs water planning processes including allocation to meet community needs and balancing economic development.[873] The coal seam gas framework contends that leading practices concerning water should include an AM framework.[874]

Some insist that in the United States the response to shale and tight gas does not reflect the cautious, structured discourse and 'process of continuous improvement' that some argue is needed, and which is the trademark of AM.[875] AM has the potential to decrease resistance to shale and tight gas production given it assists in the determining of risk, reinforcing support for research, assessment and planning, providing a basis for funding significant features of governance before shale and tight gas activities begins., i.e. hydraulic fracturing, and reducing resistance to adaptive management policy-making that strives to link contemporary science with economic, social, and value considerations.[876]

[869] Brian G. Rahm & Susan J. Riha 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci.: Processes Impacts* 1400, 1408 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H
[870] Id at 1401.
[871] The National Harmonised Regulatory Framework for Coal Seam Gas, 2013, pg 14 at http://scer.govspace.gov.au/files/2013/06/National-Harmonised-Regulatory-Framework-for-Natural-Gas-from-Coal-Seams.pdf
[872] Ibid.
[873] Id at 40.
[874] Ibid.
[875] Brian G. Rahm & Susan J. Riha 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci.: Processes Impacts* 1400, 1408 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H
[876] Id at 1410.

Although AM is an effective regulatory approach, the risks associated with hydraulic fracturing require a more 'robust, transparent and independent assessment process' which would reduce the likelihood of groundwater contamination.[877] While stakeholders continue to study the impacts of hydraulic fracturing, the question of whether to adhere to the precautionary principle in management decisions has emerged.[878] The exploitation of shale and tight gas generates a considerable risk of contamination, both to ground and surface water, and it is reasonable to contend that a precautionary approach should be used until an evidence base is developed.[879] There is a significant amount of unreliable evidence from the United States that contamination has arisen in a number of cases involving the extraction of shale and tight gas.[880] The evidence of contamination and the application of the precautionary principle in the European Union, has led to calls in the United Kingdom for a delay in shale and tight gas extraction until clear evidence of its safety can be offered.[881] The precautionary principle is used in various international treaties and declarations, as well as Australian Federal and state laws though there is no generally accepted definition of the precautionary principle.[882]

The precautionary principle, if used correctly, can guarantee that community concerns are addressed.[883] This approach has a procedural emphasis on community participation and transparency.[884] The transparency component is extremely important given the public concern about shale and tight gas.[885] Concerns with shale and tight gas production can be alleviated by transparency, i.e., operational transparency (extraction/production), and how legislators make

[877] Karen Bubna-Litic, Fracking in Australia: The future in SA? (2015) 32 *EPLJ* 437, 447

[878] Barth, E, Hydraulic Fracturing "cheat sheet" for Peer-reviewed Literature, 2012 at https://environment.yale.edu/yer/article/hydraulic-fracturing-cheat-sheet

[879] Wood, R., Shale gas: a provisional assessment of climate change and environmental impacts, 2011, pg 5 at < https://www.research.manchester.ac.uk/portal/files/36728313/FULL_TEXT.PDF>

[880] Ibid.

[881] Id at 76, 77.

[882] United Kingdom Interdepartmental Liaison Group on Risk Assessment (UK-ILGRA), The Precautionary Principle: Policy and Application, (accessed 26 September 2017) at http://www.hse.gov.uk/aboutus/meetings/committees/ilgra/pppa.htm#FOOTNOTE

[883] Elizabeth E. Bomberg, Shale Governance in the European Union: Principles and Practice, 2014, pg 8 at http://closup.umich.edu/files/ieep-2014-shale-governance-in-the-eu.pdf

[884] European Commission. (2 February 2000). Communication from the Commission of 2 February 2000 on the precautionary principle [COM(2000) 1 final]. Brussels: European Commission.

[885] International Energy Agency (IEA). (2012). Golden rules for a golden age of gas. Special Report on Unconventional Gas. Paris: IEA. Retrieved from http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf ; see also Stevens, P. (2012). The shale gas revolution: Developments and changes. Briefing Paper. London: Chatham House.

decisions about regulation.[886] The precautionary principle's transparency component affects a number of key shale policies in the European Union, for example, environmental impact assessments, chemical disclosure and the development of regulation.[887] Transparency is one of the central tenets behind the European Union's environmental impact assessment rules that are meant to permit 'transparent and democratic participation in the decision whether to allow such activities to proceed'.[888]

Some industry commentators argue that the precautionary principle or the 'better safe than sorry'[889] approach to shale and tight gas inhibits the use of new technology until risks are better understood.[890] Although the precautionary principle is used in the European Union and gained popularity in the United States, it has been rejected by some regulatory academics.[891] The precautionary principle is generally used to regulate catastrophic risks,[892] i.e., nuclear power, genetically modified organisms, human cloning, and climate change.[893] The harm caused is likely to be permanent with a considerable number of individuals impacted.[894] By comparison, hydraulic fracturing poses risks to individual aquifers.[895] Those that oppose the use of the precautionary principle for shale and tight gas accept that hydraulic fracturing can devastate an aquifer's value as a drinking source or for agricultural purposes, and as hydraulic fracturing

[886] Elizabeth E. Bomberg., Shale Governance in the European Union: Principles and Practice, 2014, pg 8 at http://closup.umich.edu/files/ieep-2014-shale-governance-in-the-eu.pdf
[887] Ibid.
[888] Francioni, F. & Bakker, C. (January 2013). The evolution of the global environmental system: Trends and prospects. Transworld Working Paper. Brussels: Transworld. Retrieved from <http://www.transworld-fp7.eu/?p=985>
[889] Frank B. Cross, Paradoxical Perils of the Precautionary Principle, (1996) 53 *Wash. & Lee L. Rev.* 851, 851
[890] See generally European Risk Forum, The Precautionary Principle: Application and Way Forward, 18–20, 2011 (defining and discussing the precautionary principle's origins)
[891] See, e.g., Cass R. Sunstein, *Laws of Fear: Beyond the Precautionary Principle* (Cambridge) (2005) (discussing various mechanisms that enable a fearful public to invoke the precautionary principle, which yields unjustified intrusions upon civil liberties).
[892] See Frederick Schauer, 'Is it Better to Be Safe than Sorry?: Free Speech and the Precautionary Principle' (2009) 36 *Pepp. L. Rev.* 301, 304–06
[893] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 205
[894] Ibid.
[895] Spence D, 'Fracking Regulations: Is Federal Hydraulic Fracturing Regulation Around the Corner? (accessed 17 June 2017) at < https://www.mccombs.utexas.edu/~/media/Files/MSB/Centers/EMIC/EMIC%20Misc/Fracking-Regulations-Is-Federal-Hydraulic-Fracturing-Regulation-Around-Corner.PDF>

becomes more common, more aquifers are put at risk.[896] The contention is that alternative sources of water are available at a cost to consumers and contaminated water can be treated.[897]

To use the precautionary principle for shale and tight gas extraction disregards the years of experience operators have with hydraulic fracturing. Operators have performed over two million fractures in the United States.[898] The evidence indicates that the risk of widespread or total destruction to water resources is remote,[899] and the likelihood of local contamination is manageable providing hydraulic fracturing is done correctly.[900] Those that support the precautionary principle insist that in the absence of scientific agreement about the potential harm from hydraulic fracturing, the onus to prove that it is safe lies with the industry.[901] In the absence of evidence that hydraulic fracturing is safe, precautions such as ceasing ongoing mining activities should be taken to protect the environment.[902]

3.7 Conclusion

This chapter provided a brief history of mineral and petroleum ownership which included an examination of indigenous rights. The chapter examined regulatory approvals focusing on environmental approvals and assessment. It also examined the various regulatory approaches that can be used to manage the exploitation of shale and tight gas.

Modern regulatory approaches are the alternative to prescriptive regulation, though it is likely other approaches are more suitable for managing the risks of shale gas and tight gas extraction.

[896] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 205

[897] See EPA, Ground Water Cleanup at Superfund Sites, December 1996 at<http://www.epa.gov/superfund/health/conmedia/gwdocs/brochure.htm> (explaining that ground water can be treated by pumping it to the surface, decontaminating it, and then discharging it back into the ground or into a stream or river).

[898] Thomas W. Merrill & David M. Schizer, 'The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy' (2013) *Minnesota Law Review* 205

[899] Spence D, 'Fracking Regulations: Is Federal Hydraulic Fracturing Regulation Around the Corner? (accessed 17 June 2017) at < https://www.mccombs.utexas.edu/~/media/Files/MSB/Centers/EMIC/EMIC%20Misc/Fracking-Regulations-Is-Federal-Hydraulic-Fracturing-Regulation-Around-Corner.PDF>

[901] Barth, E, Hydraulic Fracturing "cheat sheet" for Peer-reviewed Literature, 2012 at https://environment.yale.edu/yer/article/hydraulic-fracturing-cheat-sheet

[902] Ibid.

These modern approaches have simply adjusted the state's role by using non-government participation in encouraging regulatory compliance. Stakeholders must determine what approach or approaches might best address the different regulatory tasks likely to confront operators. The different circumstances between states does not justify regulating more or less rigorously.

4 COMPARATIVE ANALYSIS OF REGULATORY ISSUES

The social and environmental risks and challenges linked to the exploitation of shale and tight gas primarily relate to land access, water access and quality protection, the regulation of well technology for drilling and hydraulic fracturing and decommissioning and associated issues (abandonment, rehabilitation and reclamation). These and other issues have been examined in parliamentary inquiries in Western Australia and South Australia.[903]

It is highly likely that community and political antagonism toward shale and tight gas exploitation will continue unless satisfactory regulatory alternatives are developed. There are a number of international studies that have examined the risks and challenges associated with exploiting shale and tight gas, though the author argues that none have dealt in a meaningful way with the specific shortcomings and regulatory gaps that this thesis contends exist in Western Australia and South Australia.

In the author's opinion, Western Australia and South Australia's regulatory regimes are under-analysed and there are limited academic studies on the particular issues outlined in this thesis' introductory chapter (and above). Given that shale and tight gas exploitation is in its infancy in both jurisdictions, understanding all of the relevant risks and challenges is difficult.[904]

This chapter will compare land access, which includes statutory access and access agreement regimes, water quality and protection issues, which includes examining the various state based water legislation, drilling and fracturing, which includes flow-back, produced and recycled water and well and field management. The chapter will also examine decommissioning and rehabilitation.

[903] The Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, (2015)
[904] Brian G. Rahm& Susan J. Riha 'Evolving shale gas management: water resource risks, impacts, and lessons learned' (2014) 16 *Environ. Sci.: Processes Impacts* 1400, 1408 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H

4.1 Land Access

Western Australia, South Australia and Colorado all use non-statutory access agreements to manage the relationship between operators and landowners when operators seek to exploit shale and tight gas. The South Australia government maintains that 'mutual trust for compatible, sustainable land access for upstream petroleum are traditionally indemnified with formal land access agreements struck between operators, potentially affected people and enterprise.'[905] Western Australia's Standing Committee on Environment and Public Affairs recommended that the State government 'draft legislation for a statutory framework for land access agreements between land owners and resource companies'.[906] As a result, the Western Australian government established a land access working group to review the need for a statutory framework for land access.[907]

Western Australia's peak industry groups for agriculture and oil have published guidelines to assist operators and landowners to reach fair and equitable agreements.[908] DMIRS expects, but does not insist, that 'title holders engage early and often with all stakeholders including private land holders, lessees, shires and members of the community'.[909] The Standing Committee on Environment and Public Affairs identified a number of deficiencies in Western Australia's land access regime and asked the State government to consider drafting legislation for a statutory framework for land access agreements.[910]

[905] Energy Resources Division, Department of Manufacturing, Innovation, Trade, Resources and Energy, Roadmap for Unconventional Gas Projects in South Australia, 2012, pg 147 at < https://statedevelopment.sa.gov.au/upload/mineral-and-energy-resources/Roadmap_Unconventional_Gas_Projects_SA_12-12-12.pdf>

[906] The Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, Chapter 5, pg 75

[907] Land Access Working Group established, Thursday 15 September 2016 at https://www.mediastatements.wa.gov.au/Pages/Barnett/2016/09/Land-Access-Working-Group-established.aspx

[908] WA Farmers, PGA, APPEA, Vegetables WA, Farming Land Access Agreement Template for Petroleum Activities under the Petroleum and Geothermal Energy Resources Act 1967, October 2015 at http://www.appea.com.au/wp-content/uploads/2015/10/Final-Template-Access-Agreement-Oct-2015.pdf

[909] Department of Mines, Industry Regulation and Safety, Land use and access, (accessed 2 January 2018), at http://www.dmp.wa.gov.au/Petroleum/Land-use-and-access-20009.aspx

[910] The Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, Chapter 5, pg 75

Both Western Australia and South Australia's land access regimes exhibit historic efforts to mediate the interests of the state, as resource owner with the rights and interests of landholders (particularly agricultural landholders) and operators.[911] Both appear relatively comfortable with the use of access agreements. Access agreements are also used in in Colorado and are known as surface use agreement. The agreements are private contracts between operators and landowners.

South Australia's Natural Resources Committee argued that landowners should be supported when they negotiate with operators to ensure that conduct and compensation agreements are developed in a harmonious way and are mutually beneficial.[912] Further, the Committee felt that 'unfair or hastily derived compensation agreements are likely to set poor precedents and precipitate long-term damage to working relationship between petroleum and geothermal energy explorers and the community'.[913] The stand out provision in the OGCA is the reasonable accommodation provision.[914] The provision requires operators to disturb only the amount of land that is "reasonable and necessary" to extract gas.[915]

4.1.1 Statutory Access – Western Australia and South Australia

In Western Australia, operators cannot enter private land that is less than 2000 square metres, where it has been used as a cemetery or burial place or is within 150 metres of a cemetery, burial place, reservoir or any substantial improvement without written consent.[916] Regulated activities cannot be undertaken in Western Australia unless a compensation agreement has been executed or an agreement reached with a landowner or occupier.[917]

[911] Department of Mines and Petroleum, Government of Western Australia, Land Access Information Paper, 15 February 2017, pg 3
[912] Inquiry into Unconventional Gas (Fracking) in the South East of South Australia, Final Report, One Hundred Nineteenth Report of the Natural Resources Committee, Tabled in the House of Assembly and ordered to be published 29 November 2016, p 12 at <https://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=5&CId=295>
[913] Department of the Premier and Cabinet, Liaison guidelines for landowners and petroleum and geothermal energy explorers in South Australia, November 2014, pg 7, Petroleum and Geothermal Regulatory Guidelines 005 https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGRG005.pdf
[914] Section 34-60-127 of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>
[915] Section 34-60-127 of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>
[916] *Petroleum and Geothermal Energy Resources Act 1967* (WA),s 16
[917] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 20

Compensation is payable when operators deprive landowners of possession of their land, for damage to land, for damage to improvements they have made, for land separation (gas producing land from other land), for severance of rights-of-way and for consequential damages.[918] Land separation is quite a significant issue for farmers.[919] If operators and landowners fail to agree to an amount of compensation offered, either party can apply to the Magistrates Court to have an amount of compensation fixed.[920]

In South Australia, operators must provide written notice to landowners at least 21 days prior to entry.[921] They must notify a landowner of their intention to enter the land and, if they propose to carry out regulated activities, the nature of the activities.[922] Operators must describe the proposed activities, where they will be carried out, the duration, any associated consequences, actions to manage and address the consequences, the impact or potential impact of the activities on the land, whether the owner may object to entry and provide reasonable information on the rights of an owner to claim compensation.[923]

Landowners can object to an operator entering their land within 14 days of the operator's notice of intended entry.[924] An operator must notify the Minister if they receive a notice of objection from a landowner disputing entry.[925] Both parties can apply to the Warden's Court for a resolution of the dispute.[926] The Warden's Court can determine terms on which the licensee may enter the land and carry out regulated activities on the land.[927]

Any compensation a landowner receives must be connected to the them as the landowner and not a third party and cover their deprivation or impairment of the use and enjoyment, damage (not including damage that has been addressed by the operator), damage to, or disturbance of, any business or other activity lawfully conducted on the land, and for consequential loss

[918] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 17(2)
[919] *Environment and Communications Legislation Committee* (Cth), Inquiry into the *Landholders' Right to Refuse (Gas and Coal) Bill 2015*, pg 13-14
[920] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s17(4)
[921] *Petroleum and Geothermal Energy Act 2000* (SA), s 61
[922] *Petroleum and Geothermal Energy Act 2000* (SA), s 61(b)
[923] *Petroleum and Geothermal Energy Regulations 2013* (SA), r 22
[924] *Petroleum and Geothermal Energy Act 2000* (SA), s 62(2)
[925] *Petroleum and Geothermal Energy Act 2000* (SA), s 62(3)
[926] *Petroleum and Geothermal Energy Act 2000* (SA), s 62(5)
[927] *Petroleum and Geothermal Energy Act 2000* (SA), s 62(6)

suffered or incurred by the landowner as a result of the operator entering the land and carrying out regulated activities.[928]

Compensation is not payable for value or possible value of the regulated resource contained in the land.[929] The compensation may consist of an additional amount incurred by a landowner in connection with any negotiation or dispute related to the operator gaining access to the land and the activities to be carried out on the land and the compensation to be paid.[930]

If the activities of an operator significantly impair the landowner's use and enjoyment of the land, a landowner may apply to the relevant court for an order that the operator acquire the land.[931] The court may make an order transferring the land to the operator, order the operator to pay to the owner an amount equal to the market value of the land and a further amount the court considers just by way of compensation for disturbance.[932] The compensation provisions are essentially an 'umbrella' that sits over the negotiations. The author favours a statutory provision that ensures that landowners are involved in discussions.

4.1.2 Statutory Access – Colorado

Some industry commentators argue that Colorado has a vested interest in protecting mineral rights.[933] Colorado's land board is responsible for three million acres of land and four million acres of mineral rights that were ceded to the State from the Federal government at the time of statehood.[934] As a result of split estate issues, the State's mineral property can be underneath private or municipal owned surface land.[935]

The reasonable accommodation provision is a proactive attempt by Colorado to manage the interests of operators and landowners in the exploitation of shale and tight gas. Even the use

[928] *Petroleum and Geothermal Energy Act 2000* (SA), s 63(2)
[929] *Petroleum and Geothermal Energy Act 2000* (SA), s 63(3)
[930] *Petroleum and Geothermal Energy Act 2000* (SA), s 63(3a)
[931] *Petroleum and Geothermal Energy Act 2000* (SA), s 64(1)
[932] *Petroleum and Geothermal Energy Act 2000* (SA), s 64(2)
[933] Stacia S. Ryder and Peter M. Hall, 'This land is your land, maybe: A historical institutionalist analysis for contextualizing split estate conflicts in U.S unconventional oil and gas development'(2017) 63 *Land Use Policy* 149-159, 156
[934] Ibid.
[935] Ibid.

of the word 'reasonable' is more palatable than 'compensation' which is typically linked to money awarded to someone in recognition of loss, suffering or injury. The provision deals with reasonable use and accommodation, sanctions compensatory damages and equitable relief and does not impinge common law tort actions or contract rights.[936]

One industry commentator argues that the issue with split estates was dealt with as part of an overhaul of Colorado's oil and gas regulations in 2007, which codified the accommodation doctrine rooted in *Gerrity Oil and Gas Corp. v. Magness 923 P.2d 261 (1995).*[937] The laws extended surface rights to compel operators to consider surface rights of owners, minimise surface use and damage, use alternative means (if they are available) to mitigate surface intrusion and bear the burden of proof if a lawsuit is filed as a result of their failure to minimise intrusion.[938]

Some industry commentators insist that the law clarified the legal situation between mineral and surface owners, suggesting that it was in the public's interest, 'as substantial increases in the amount of oil and gas operations and the number of rural residents (were resulting) in numerous conflicts between surface owners and oil and gas operators'.[939] Colorado operations must be conducted in a way that assists surface owners and minimises intrusion upon and damage to surface lands.[940] This is achieved by 'selecting alternative locations for wells, roads, pipelines, or production facilities, or employing alternative means of operation, that prevent, reduce, or mitigate the impacts of the oil and gas operations on the surface where such alternatives are technologically sound, economically practicable, and reasonably available to the operator'.[941]

If an operator fails to meet the requirements set out in the reasonable accommodation provision, a surface owner may seek compensatory damages or such equitable relief.[942] If litigation

[936] Reasonable Accommodation, Colo. Rev. Stat §34-60-127
[937] Stacia S. Ryder and Peter M. Hall, 'This land is your land, maybe: A historical institutionalist analysis for contextualizing split estate conflicts in U.S unconventional oil and gas development'(2017) 63 *Land Use Policy* 149-159, 155
[938] Ibid.
[939] Ibid.
[940] Section 34-60-127 of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>
[941]Section 34-60-127(1)(b) of the OGC Act at http://www.lexisnexis.com/hottopics/Colorado/
[942] Section 34-60-127(2) of the OGC Act at http://www.lexisnexis.com/hottopics/Colorado/

occurs, a surface owner can present evidence that the operator's use of the surface substantially affected the surface owner's use of the surface of the land.[943] An operator must show that it met the standard set out in the provision.[944] As an affirmative defence, an operator may argue that it has conducted its operations in accordance with a regulatory obligation, contractual obligation, or land use plan that is specifically applicable to the alleged intrusion or damage.[945]

The standard of conduct set out in the reasonable accommodation provision does not preclude an operator from entering private property and using the surface as is reasonable and necessary to explore for, develop, and produce oil and gas.[946] The accommodation doctrine was first recognised by the Texas Supreme Court in *Getty Oil Company v. Jones*, 470 S.W.2d (618 (Tex.1971). Some industry commentators suggest that it served to readjust the position between mineral and surface estates back toward the equilibrium.[947] The issue in *Getty* was the height of oil pumps installed by Getty Oil. Jones argued that the oil pumps interfered with the sprinkler system he used to irrigate his property, and as a result much of his land could not be used to grow crops.[948] Jones asked Getty Oil to either install other pumps or dig "cellars" to lower the height of the pumps. Evidence was provided to the court that indicated that neither option would be very expensive or would impact production.

The Supreme Court held that 'Getty Oil had to 'reasonably accommodate' Jones' use of the surface'.[949] The court held that a mineral owner may be compelled to accommodate a surface owner when there is an existing surface use, the mineral owner's use of the surface impedes or damages the existing use of the surface and under recognised industry practices, there are other options available to recover the minerals.[950]

Some industry commentators argue that although Colorado's reasonable accommodation provision 'is sparse and not well defined…the COGCC, has numerous regulations that speak

[943] Section 34-60-127(3)(a) of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>
[944] Ibid
[945] Section 34-60-127(3)(b) of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>
[946] Section 34-60-127(1)(c) of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>
[947] Robert J Burnett, 'The Accommodation Doctrine: Balancing the Interests of the Surface Owner and the Mineral Owner', Houston Harbaugh, Attorneys at Law, (accessed 12 April 2018) at < https://www.hh-law.com/the-accommodation-doctrine-balancing-the-interests-of-the-surface-owner-and-the-mineral-owner/>
[948] Getty Oil, 470 S.W.2d at 620
[949] Getty Oil, 470 S.W.2d at 621
[950] Getty Oil, 470 S.W.2d at 622

on the issue...this makes the COGCC's administrative procedure unusually relevant to surface owners seeking surface use agreements, contract enforcement, damages, or other remedies'.[951] Some industry commentators have criticised the accommodation doctrine on the grounds that it creates doubt because courts have been left to question the practicality of the business judgement of operators.[952] Some industry commentators argue that the accommodation doctrine can fail to take into account the increased risks associated with alternatives, such as directional drilling.[953]

The PGERA and PGEA should include a reasonable accommodation provision that requires operators to conduct their activities in a way that assists surface owners and minimises intrusion upon and damage to surface lands. This can be easily achieved by operators and landowners choosing different locations for wells, roads, pipelines, or production facilities, or using alternative means of operation, that prevent, reduce, or mitigate the impacts of the oil and gas operations on the surface where such alternatives are technologically sound, economically practicable, and reasonably available to the operator.

4.1.3 Land access agreements – Western Australia and South Australia

In Western Australia, a land access agreement template[954], explanation document[955] and farmer's guide assists farmers and operators when they are negotiating land access for the purpose of exploiting shale and tight gas.[956] The guide states that the first question landowners should ask operators when they are approached is 'what are your plans and when do you think work will start?'[957] The guide urges farmers to coordinate with their neighbours if they will

[951] Catherine Toan, Esq, Split Estates, Colorado Environmental Law Ltd, (accessed 16 June 2017) at http://www.oilandgasbmps.org/docs/GEN324_split%20estates.pdf
[952] Jeanine Feriancek & Cynthia L. McNeil, 'Oil Company Surface Use: Do Farmers Need Protection?' (1995) Winter 28 *Nat. Resources and Env't* 31
[953] Ibid.
[954] WA Farmers, PGA, APPEA, Vegetables WA, Farming Land Access Agreement Template for Petroleum Activities under the Petroleum and Geothermal Energy Resources Act 1967, October 2015 at http://www.appea.com.au/wp-content/uploads/2015/10/Final-Template-Access-Agreement-Oct-2015.pdf
[955] WA Farmers, PGA, APPEA, Vegetables WA, Explanation of the Land Access Agreement Template for Petroleum Activities under the Petroleum and Geothermal Energy Resources Act 1967, October 2015 at https://www.appea.com.au/wp-content/uploads/2015/10/Final-Land-Access-Template-Explanation-Oct-2015.pdf
[956] WA Farmers, PGA, APPEA, Vegetables WA, A Farmer's guide to Land Access for Petroleum Activities under the Petroleum and Geothermal Energy Resources Act 1967, October 2015 at https://www.appea.com.au/wp-content/uploads/2015/10/Final-Farmers-Guide-to-Land-Access-Oct-2015.pdf
[957] Id at 3.

also be affected by the same operation, obtain independent legal advice and educate themselves about environmental monitoring and regulation.[958] The guide was drafted to deal only with the exploration phase of shale and tight gas development and it points out that a proposal for field development and commercial production must be dealt with under a separate agreement.[959]

The guide asks farmers to consider how exploration activities can deliver long term improvements to farms, pointing out that exploration activity can involve operators building infrastructure like roads, water bores, fencing and power supply.[960] It goes further and indicates that, in certain cases, infrastructure can be retained and used by farmers and that, in some cases, operators may even hire farmers to carry out rehabilitation work pending approval from regulators.[961] A model agreement was developed to assist with negotiations.[962] The aim of the agreement is to deliver fairness and equity to negotiating parties when they are discussing access and compensation.[963]

According to the guide the most important elements of a model agreement are that operators minimise disturbance to farming assets and operations, that farmers allow exploration to proceed without unnecessary disruption once an agreement has been reached, that there is prior communication on operational activities, locations, equipment use, fire management and other relevant information, that operators are aware of their obligations to cover reasonable costs, including proposals for legal and financial advice, other costs directly related to preparing the agreement, and technical advice is provided on the impacts of petroleum exploration.[964]

South Australia's liaison guidelines set out that operators should establish good relationships with landowners so as to facilitate, amongst other things, arrangements regarding infrastructure (e.g water sources, roads, tracks, fences, gates), the meeting of regulatory requirements and to facilitate negotiating fair compensation.[965]

[958] Ibid.
[959] Id at 2.
[960] Ibid.
[961] Ibid.
[962] Id at 5.
[963] Ibid.
[964] Id at 7.
[965] Department of State Development, (SA), Liaison guidelines for landowners and petroleum and geothermal energy explorers in SA, Petroleum and Geothermal Regulatory Guidelines 005, Version 1.1, November 2014, pg 4

The liaison guidelines explicitly set out that operators are expected, amongst other things, to avoid damage to improvements and manage activities whilst considering their effects on vegetation and soil, avoid interfering with crops, livestock and other economic activities on the property, avoid disturbance to dwellings and pay compensation promptly.[966] The guidelines specify that a landowner's contribution is to provide adequate contact details, respond to requests for information issued under the PGEA and advise operators of any changes to stock and management programs.[967] The South Australian guidelines stipulate that landowners should be provided with, amongst other things, details of proposed activities, including, the proposed location of fieldwork, the extent and type of the operations to be conducted and proposed techniques or options that address any landowner concerns.[968]

The author does not favour the use of land access agreements to manage the operator/landowner relationship in the absence of a statutory foundation. Neither does the author favour the compensation provision contained within the PGERA and PGEA. Land access agreements in Western Australia are private agreements to which DMIRS is not a party.[969] This is also the case in South Australia. As has been publicly stated by DMIRS, 'PGERA land access agreements are private negotiations…DMP is not a party to the arrangements or their negotiation'.[970] DMIRS is also on record stating that access agreements can be used to 'determine which areas of land can be accessed and how often, which entrance and access tracks vehicles are permitted to use and the land owner's preferred method of communication'.[971]

A good faith clause should be inserted into the PGERA and PGEA similar to the one contained in the COGCC rules.[972] The COGCC requires operators to meet in 'good faith' with landowners to negotiate surface use agreements. These meetings deal with the location of

[966] Ibid.
[967] Ibid.
[968] Id at 6.
[969] Department of Mines, Industry Regulation and Safety, Land Access Information Paper, 15 February 2017, pg 7 at http://www.dmp.wa.gov.au/Documents/About-Us-Careers/Land_Access_Information_Paper.pdf
[970] Ibid.
[971] Department of Mines, Industry Regulation and Safety, Land use and access, (accessed 15 June 2017) at http://www.dmp.wa.gov.au/Petroleum/Land-use-and-access-20009.aspx
[972] Colorado Oil & Gas Conservation Commission, Department of Natural Resources, Information for Surface Owners, (accessed 18 June 2017) at https://cogcc.state.co.us/documents/about/Help/Surface%20Owners%20Brochure.pdf

roads, production facilities, well sites, other oil and gas operations and reclamation and abandonment.[973] Meetings should occur at an agreed time and before the use of heavy equipment.[974] The COGCC rules explicitly provide landowners and occupiers with the opportunity to provide feedback on favoured locations for wells and associated production facilities, the timing of oil and gas operations, and mitigation measures or best management practices to be used during operations.[975] The PGEA regulations stipulate that operators must advise and confer with landowners and provide adequate information to assist them in making informed decisions about the impact or possible impact of the proposed operation.

4.1.4 Surface use agreements - Colorado

Surface use agreements are private contracts that deal with an operator's activities on the surface owner's property.[976] The COGCC has no authority over terms of a surface use agreement.[977] The landowner's guide encourages the drafting of protective leases in surface use agreements.[978] The Colorado guide advocates for the inclusion of a primary term of a standard lease (typically 3-5 years).[979] During this time operators must drill a well and, if they fail to do so, their lease expires. The secondary term continues as long as the wells on the property are producing gas.[980] The Colorado guide encourages landowners to include a *pugh clause* in leases so that land not in production can split from acreage in production.[981] This protects landowners from the irregularity of having their entire property held under a lease by production from a very small portion.[982] When the primary term of a lease ends, only the land being developed is held into the secondary

[973] Rule 306 of the COGCC rules at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[974] Rule 306(a) of the COGCC rules at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[975] COGGC rules, Series drilling, development, production and abandonment, (accessed 18 June 2017) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[976] Colorado Oil & Gas Conservation Commission, Department of Natural Resources, Information for Surface Owners, (accessed 17 June 2017) at https://cogcc.state.co.us/documents/about/Help/Surface%20Owners%20Brochure.pdf
[977] Ibid.
[978] Matt Sura, Colorado Landowner's Guide to Oil and Gas Development, (accessed 15 May 2017) at http://www.oilandgasbmps.org/landowners-guide/
[979] Ibid.
[980] Matt Sura, A Protective Lease, Colorado Landowner's Guide to Oil and Gas Development,(accessed 18 May 2017) at http://www.oilandgasbmps.org/landowners-guide/
[981] US Legal, Pugh Clause Law and Legal Definition at < https://definitions.uslegal.com/p/pugh-clause/>
[982] *Roseberry v. Louisiana Land & Exploration Co*., 470 So. 2d 178 (La. Ct. App. 1985)

term.[983] Non-producing land can be re-leased to the same operator or leased to another operator.[984]

A standard industry lease gives an operator the right to, 'unimpeded ingress and access to the leased lands', and the 'right to use so much of the surface, and at such locations, as may be necessary or convenient for lessee's oil and gas operations.'[985] Under a standard industry lease, the operator may use as much of the landowner's surface as they wish.[986] The Colorado guide encourages landowners to include certain items in a surface use agreement as part of their lease.[987]

Operators in Colorado are normally willing to enter into surface use agreements in order to gain timely and trouble free access and use of the surface.[988] Where there is no split estate, the lease with the fee owner will regularly include surface damage provisions, with itemised payments and provisions that restrict surface use to what is needed, specifying the size of the site, identifying the locations and width of access roads and rights of way, and demanding fencing.[989] Where an operator is unable or unwilling to negotiate a surface use agreement when a lease is signed, a provision can be added that states, 'any entry or location of facilities on the surface property is forbidden without permission granted through a separate surface use agreement.'[990]

The Colorado guide urges landowners to ensure surface use agreements indicate the location of wells given that directional or horizontally drilled wells allow for well pads to be placed some distance away from gas deposits.[991] It encourages landowners to discuss the location of wells with operators and, where wells must to be located on a landowner's

[983] Matt Sura, A Protective Lease, Colorado Landowner's Guide to Oil and Gas Development, (accessed 17 June 2017) at http://www.oilandgasbmps.org/landowners-guide/
[984] Ibid.
[985] Ibid.
[986] Ibid.
[987] Ibid.
[988] Kendor P. Jones, John F. (Jeff) Welborn, Chelsey J. Russell 'Split Estates and Surface Access Issues' *Landman's Legal Handbook* Chapter 9 (Rocky Mt. Min. L. FDN., 5th ed., 2013), pg 193
[989] Ibid.
[990] Matt Sura, A Protective Lease, Colorado Landowner's Guide to Oil and Gas Development, (accessed 18 June 2017) at http://www.oilandgasbmps.org/landowners-guide/
[991] Matt Sura, Location of the well(s), Colorado Landowner's Guide to Oil and Gas Development, Part VI – Negotiating with the Oil and Gas Industry, C. Surface Use Agreement, (accessed 17 June 2017) at http://www.oilandgasbmps.org/landowners-guide/#7

property, consideration should be given to truck traffic, noise, and odours from gas facilities.[992] Surface use agreements should state whether operators intend to use multi-well pads, i.e., whether they intend to co-locate wells on single well pads to minimise surface impacts.[993] The co-location of wells can result in much larger facilities, the generation of more air emissions, noise, traffic, light, result in longer drilling times and should be located away from homes.[994]

Landowners in Colorado are encouraged to negotiate the location of roads and vehicle access, in particular whether there is an intention to construct temporary roads or whether they will be built to specific standards.[995] The guide suggests that consideration should be given to drilling wells near existing roads.[996]

Landowners are encouraged to negotiate transportation plans with operators.[997] Agreements should outline the frequency of an operator's entry to a landowner's property.[998] According to the guide, it can take 2,000 *round trip truck trips* to drill a well.[999] After a well is drilled, consideration should be given to the frequency of monitoring.[1000] Landowners should establish whether they will consent to extra gas facilities (such as processing facilities, compressor engines, or temporary worker housing) being located on their property. Surface use agreements should deal with the issue of additional equipment and facilities.[1001]

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[992] Ibid.
[993] Matt Sura, Multi-well pads, Colorado Landowner's Guide to Oil and Gas Development, Part VI – Negotiating with the Oil and Gas Industry, C. Surface Use Agreement, (17 June 2017) at http://www.oilandgasbmps.org/landowners-guide/#7
[994] Ibid.
[995] Matt Sura, Location of roads and vehicle access, Colorado Landowner's Guide to Oil and Gas Development, Part VI – Negotiating with the Oil and Gas Industry, C. Surface Use Agreement, (accessed 17 June 2017) at http://www.oilandgasbmps.org/landowners-guide/#7
[996] Ibid.
[997] Matt Sura, Transportation plans, Colorado Landowner's Guide to Oil and Gas Development, Part VI – Negotiating with the Oil and Gas Industry, C. Surface Use Agreement, (accessed 17 June 2017) at http://www.oilandgasbmps.org/landowners-guide/#7
[998] Ibid.
[999] Ibid.
[1000] Ibid.
[1001] Mattt Sura, Additional equipment and facilities, Colorado Landowner's Guide to Oil and Gas Development, Part VI – Negotiating with the Oil and Gas Industry, C. Surface Use Agreement, (accessed 17 June 2017) at <http://www.oilandgasbmps.org/landowners-guide/#7

When drafting surface use agreements the Colorado guide encourages landowners to take into account the possibility of surface disturbance; interim reclamation (what will land look like when operators are finished extracting gas); pits (will waste storage be allowed on a property); waste disposal (how will liquid and solid waste be disposed of); groundwater impacts; noise impacts; dust impacts; visual impacts; water rights; fencing; damages; timing (the timing of the operations and whether they will disrupt agricultural uses) and current use (are there current or future uses of the land that must be accommodated eg. livestock, irrigated farmland, future housing development, etc.).

There are various protections that can be included as requirements for approval in drilling permits or oil and gas location assessments[1002] which are enforced by the COGCC.[1003] The Colorado guide suggests that these inspections give surface owners an opportunity to influence COGCC staff to insert additional protective conditions into the drilling permit.[1004] The COGCC is not involved in surface owner compensation issues or other private party negotiations between an operator and the surface owner.[1005] A landowner with no right to minerals below the surface can influence negotiations by relying on the 'reasonable accommodation' provision in the OGCA.[1006]

4.1.5 Conclusion

The use of non-statutory based access agreements in Western Australia and South Australia is not appropriate to manage the relationship between operators and landowners. The author has no faith in the use of these agreements if they are not underpinned by legislation. These agreements are private agreements and it is highly likely that any power imbalances, whether real or perceived, would be alleviated by some involvement by the respective state regulators in the negotiation process. For example, it should not be left to industry groups to develop guidelines and tools to assist petroleum title holders and farmers to reach fair and equitable

[1002] Rule 303(b) of the COGCC at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf>; Form 2A at <https://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/Form2A_20130806.pdf>
[1003] Colorado Oil and Gas Conservation Commission, Enforcement Guidance and Penalty Policy, January 2015 at <http://cogcc.state.co.us/documents/reg/Policies/EnforcementGuidance.pdf>
[1004] Rule 303 of the COGCC at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf>
[1005] Matt Sura, Colorado Landowner's Guide to Oil and Gas Development, B. "Bonding On" Without a surface use agreement, (accessed 17 June 2017) at http://www.oilandgasbmps.org/landowners-guide/#7
[1006] Section 34-60-127 of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>

agreements.[1007] Western Australia's land access regime would benefit if the DMIRS expectation of stakeholder interaction had a statutory foundation. The author favours Colorado's reasonable accommodation provision as a mechanism to assist landowners in their negotiations with operators.[1008] The provision requires operators to only disturb the amount of land that is "reasonable and necessary" to extract gas.[1009]

4.2 Water

Water is likely to dominate the shale and tight gas debate for the foreseeable future.[1010] Some industry commentators argue that 'drought and increasing competition for water have only heightened the need for effective water management strategies.'[1011] The implementation of effective water management and regulatory regimes to protect water resources and the encouragement of sustainable practices and efficient use will enable operators to exploit shale and tight gas with less community opposition. There is little disagreement that the handling and disposal of waste water is the single greatest environmental impediment to natural gas and oil exploration and production.[1012]

[1007] WA Farmers, PGA, APPEA, Vegetables WA, Explanation of the Land Access Agreement Template for Petroleum Activities under the Petroleum and Geothermal Energy Resources Act 1967, October 2015 at https://www.appea.com.au/wp-content/uploads/2015/10/Final-Land-Access-Template-Explanation-Oct-2015.pdf

[1008] Section 34-60-127 of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>

[1009] Section 34-60-127 of the OGC Act at <http://www.lexisnexis.com/hottopics/Colorado/>

[1010] Carlos R. Romo & Molly Cage, State policy and technological innovation in hydraulic fracturing water management, ABA Section of Environment, Energy and Resources, Trends March/April 2014

[1011] Ibid

[1012] World Energy Outlook, Golden Rules for Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, (2012) at 32 at < https://www.iea.org/media/training/presentations/etw2014/Day_2_Session_2b_Gas_Unconventional.pdf>

4.2.1 Australia - EPBC Act

The *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) sets out that 'actions that have, or are likely to have, a significant impact on a matter of national significance require approval from the Commonwealth Minister for Environment'.[1013] In Australia water resources are considered a matter of national environmental significance (MNES), with regard to coal seam gas development and large coal mining development (water trigger). A water resource is ground water or surface water and comprises organisms and ecosystems that add to the environmental value and physical state of the water resource.[1014]

The water trigger ensures that the impacts of planned coal seam gas development and large coal mining developments on water resources are appropriately assessed.[1015] The water trigger does not apply to shale and tight gas. The amendments to the EPBC Act were based on the objectives of the *National Partnership Agreement on Coal Seam Gas and Large Coal Mining* (NPA).1016 An independent review of the water trigger legislation was tabled in the Commonwealth Parliament in 2017.[1017] When the EPBC Act amendments were considered, some argued its scope should have been expanded to include shale and tight gas.[1018] The independent review insisted that the exclusion of shale and tight gas was deliberate.[1019] Specifically, the review determined that:

> '…the objective of the legislation is clear and narrow. It seeks to deal only with the impacts on water resources of coal seam gas and large coal mining development. Therefore, the review cannot conclude that the silence of the legislation on shale and tight gas is other than intentional.'[1020]

[1013] Department of Environment and Energy, What is protected under the EPBC Act, (accessed 19 June 2017) at < http://www.environment.gov.au/epbc/what-is-protected>
[1014] Water resources – 2013 EPBC Act amendment – Water trigger, (accessed 17 June 2017) at http://environment.gov.au/epbc/what-is-protected/water-resources
[1015] Ibid.
[1016] Department of Environment and Energy, National Partnership Agreement on Coal Seam Gas and Large Coal Mining Development, (accessed 17 June 2017) at http://www.environment.gov.au/water/coal-and-coal-seam-gas/office-of-water-science/npa
[1017] Stephen Hunter, Independent Review of the Water Trigger Legislation, April 2017 at < http://www.environment.gov.au/system/files/resources/905b3199-4586-4f65-9c03-8182492f0641/files/water-trigger-review-final.pdf>
[1018] Stephen Hunter, Independent Review of the Water Trigger Legislation, April 2017, p 33
[1019] Stephen Hunter, Independent Review of the Water Trigger Legislation, April 2017, p 50
[1020] Stephen Hunter, Independent Review of the Water Trigger Legislation, April 2017, p 50

Western Australia's Standing Committee on Environment and Public Affair identified 'that the emergence of an unconventional gas industry in WA was a source of community interest and concern'.[1021] Several years later, the Commonwealth government advised a select committee on unconventional gas that the remoteness and scale of Australia's shale gas and tight gas operations has, to date, reduced community impact and concern.[1022]

The handling and disposal of water is the single greatest environmental obstacle to shale and tight gas exploitation and it is concerning that the water trigger has not been extended. It is likely that the exploitation of shale and tight gas will threaten water resources in some way. The negative impacts on water resources, if not properly managed, have the capacity to cause significant environmental and production issues beyond immediate production areas. There is also a risk to drinking water supplies through contamination. The EPBC Act should include shale and tight gas as a water trigger.

4.2.2 The United States

The *Pollution Control Act of 1948* (United States) was the first major United States law to address water pollution. It authorised the Surgeon General of the Public Health Service to prepare comprehensive programs for eradicating or decreasing the pollution of interstate waters and tributaries and improving the sanitary condition of surface and underground waters.[1023] Increased public awareness and concerns for controlling water pollution in the United States at the time led to comprehensive amendments in 1972.

The result of these amendments was the *Federal Water Pollution Control Act of 1948* (United States) or as it widely known, the *Clean Water Act* (CWA). The CWA established the structure

[1021] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015

[1022] Australian Government Submission to the Select Committee on Unconventional Gas Mining, Unconventional Gas Mining Submission 123, March 2016 http://www.parliament.wa.gov.au/Parliament/commit.nsf/RelatedReportsLookup/74E61E739E39E57748257EF9002150FE?OpenDocument https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Gasmining/Gasmining/Submissions

[1023] United States Environmental Protection Agency, Laws and Regulations, History of the Clean Water Act (15 January 2018)

for regulating pollutant discharges; gave the US Environmental Protection Agency (EPA) the authority to implement pollution control programs; maintain existing requirements to set water quality standards for all contaminants in surface water; made it unlawful to discharge pollutants; funded the construction of sewerage treatment plants and recognised the need for planning to address the critical problems posed by nonpoint source pollution.[1024] The CWA outlines the National Pollutant Discharge Elimination System (NPDES) permit process which establishes limits on produced water discharge.

The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (United States) (CERCLA) provided a 'superfund' to 'clean up uncontrolled or abandoned hazardous waste sites as well as accidents, spills, and other emergency releases or pollutants and contaminants into the environment'.[1025] Shale gas production in the United States is not subject to CERCLA.[1026] The *Safe Drinking Water Act of 1974* (United States) (SDWA) was implemented to protect the quality of drinking water in the United States.[1027] The SDWA sanctioned the EPA to establish minimum standards to protect tap water and required all owners or operators of public water systems to comply.[1028] The Underground Injection Control program was launched by the SDWA to protect underground drinking water from contamination.

The *Energy Policy Act of 2005* (United States) exempted hydraulic fracturing from the SDWA and CWA. A provision in the Act sets out that the definition of 'underground injection' did not include the injection of fluids or specified propping agents. This provided an exemption for drilling and extraction activities and the requirement of groundwater contamination under the SDWA. The *Fracturing Responsibility and Awareness of Chemicals Act of 2017* (United States) (the Frac Act) was introduced into Congress in 2017 to amend the SDWA to repeal the hydraulic fracturing exemption.[1029]

[1024] Ibid.
[1025] United States Environmental Protection Agency, Laws and Regulations, Summary of the Comprehensive Environmental Response, Compensation and Liability Act (Superfund) (15 January 2018)
[1026] Simon Robb, 'A best practice regulatory proposal for shale gas production', Doctor of Juridical Science thesis, The University of Western Australia, 2014, pg 116
[1027] United States Environmental Protection Agency, Laws and Regulations, Summary of the Safe Drinking Water Act (15 January 2018)
[1028] Ibid.
[1029] *The Frac Act* (2017) (United States) at https://www.congress.gov/bill/115th-congress/senate-bill/865/text

4.2.3 Western Australia

The use of water in hydraulic fracturing is regulated by three statutes: the PGERA that regulates petroleum exploration and production activities; the RiWI Act that regulates the taking and use of water; and the environmental protection legislation that regulates discharges of waste. The PGERA is administered by the DMIRS and the water resources and environmental protection legislation by the DoWER.

The PGERA gives operators land tenure access to water resources under the authorisation of a permit, drilling reservation, access authority, special prospecting authority, lease or licence.[1030] The taking and use of water for the purposes of gas operations is subject to the RiWI Act.[1031] The right to the use, flow and control of water in Western Australia is vested in the Crown and, in most cases, activities for the taking of water resources needs specific licence authority.[1032] The construction of all artesian wells or bores, and all non-artesian wells within proclaimed groundwater management areas, also needs to be licensed.[1033] Western Australian operators require licences if they want to take water for drilling wells and for hydraulic fracturing.[1034] There is no licencing instrument under the RiWI Act to regulate the injection of water or fluids into the ground for hydraulic fracturing activities. These activities are regulated under PGERA. The reuse or disposal of wastewater is regulated in accordance with the PGERA Environment Regulations as part of the approvals process.

The DoWER and DMIRS have an administrative agreement in place to support co-operation in relation to the consideration of potential impacts on water resources by petroleum and geothermal activities regulated under the PGERA.[1035] If the DMIRS receives an EP proposing petroleum activities in 'a public drinking water source area or within five kilometres of public drinking water source area water bore or aboriginal community drinking water bore', the DMIRS provides the DoWER with a copy of the EP and asks that they provide advice on the

[1030] *Petroleum and Geothermal Energy Resources Act 1967* (WA), s 7
[1031] *Petroleum and Geothermal Energy Resources Act* 1967 (WA), s 7(3)
[1032] *Rights in Water and Irrigation Act 1914* (WA), ss 5A and 5C.
[1033] *Rights in Water and Irrigation Act 1914* (WA), ss 26A and 26D
[1034] *Rights in Water and Irrigation Act 1914* (WA), s 5C
[1035] Administrative Agreement between the DMIRS and DoW For Onshore Petroleum and Geothermal Activities in Western Australia, July 2015 at http://www.water.wa.gov.au/__data/assets/pdf_file/0007/7468/109380.pdf

proposal and not approve it until advice is obtained.[1036] If the DMIRS receives an EP proposing petroleum activities outside a public drinking water source area they will provide a copy to the DoWER.[1037] The DoWER will advise the DMIRS whether they want to review the EP and request that it not be approved until they have provided comment.[1038]

There is a capacity under Part V of the *Environmental Protection Act 1986* (WA) (EP Act) to manage the impacts of specific development projects on water resources.[1039] Under Part V Division 3, specified industrial premises that could cause emissions and discharges to air, land or water are known as 'prescribed premises' and trigger regulation by the DoWER.[1040] Natural gas processing facilities become prescribed if they process more than 5,000 tonnes of gas per year.[1041] The DoWER regulates the construction and operation of above ground facilities after gas has been extracted from below the ground.[1042] It does not regulate the extraction of gas that occurs below the ground which includes the construction and installation of gas wells, and the operation of hydraulic fracture stimulation processes.[1043]

Western Australia's guideline for groundwater monitoring for shale and tight gas operations applies to monitoring of groundwater resources for regulated activities under the PGERA and associated regulations.[1044] The guideline covers groundwater monitoring programs for new shale and tight gas operations with regard to drilling, well construction, well work-over, injection, well production testing, hydraulic fracture stimulation, construction and installation

[1036] Id at 4.
[1037] Ibid.
[1038] Ibid.
[1039] *Environmental Protection Act 1986* (WA), Part V
[1040] Department of Environment Regulation, Government of Western Australia, Regulation of natural gas from shale and tight rocks, Industry Regulation Fact Sheet 1, (accessed 18 June 2017) at https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/fact-sheet/regulation_of_natural_gas_fs.pdf
[1041] *Environmental Protection Regulations 1987*(WA), Category 10, Schedule 1
[1042] Department of Environment Regulation, Government of Western Australia, Regulation of natural gas from shale and tight rocks, Industry Regulation Fact Sheet 1, (accessed 19 June 2017) at https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/fact-sheet/regulation_of_natural_gas_fs.pdf
[1043] Ibid.
[1044] Department Mines and Petroleum and Department of Water, Guideline for Groundwater Monitoring in the Onshore Petroleum and Geothermal Industry, , July 2016, pg 4, http://www.water.wa.gov.au/__data/assets/pdf_file/0019/8812/164265_Groundwater-Monitoring_Guideline.pdf

of a facility, operation and modification of a facility, storage and processing of petroleum and decommissioning of a well or facility.[1045]

The requirements to monitor groundwater are established on a case-by-case basis subject to the scale and type of operation, level of risk and sensitivity and values of the environment (including aquifers).[1046] If there is an increased risk that groundwater resources or sensitive environments will be negatively impacted, more intensive baseline and surveillance groundwater monitoring programs may be required – including multiple monitoring bores at different locations and depths in the aquifer, along with greater sampling frequency and with additional chemical parameters.[1047]

According to the guideline, rigorous monitoring programs are suitable where activities are occurring in areas that are close to potable water supplies such as public drinking water source areas (PDWSA), a PDWSA water bore, Aboriginal community drinking water bore, close to environmentally sensitive areas, in geological areas where there is the potential to rapidly mobilise groundwater contaminants such as faults and karst geology, areas with important groundwater values and beneficial uses, close to populated areas, culturally significant areas and where there is significant public concern or perceived risks, where there is a known risk of groundwater contamination, areas with higher operational risks, or where the proposed activity has a high level of complexity, uncertainty or risk.[1048]

Those activities that pose a low risk to groundwater or are occurring in areas where there are no sensitive or water-dependent environments or water users in the vicinity of the proposed activity require less intensive monitoring programs.[1049] The guideline states that there may be activities where groundwater monitoring is not considered appropriate, for example seismic, geological and aerial surveys, construction and operation of pipelines, small scale geothermal wells.[1050]

[1045] Ibid.
[1046] Id at 5.
[1047] Ibid.
[1048] Ibid.
[1049] Id at 6.
[1050] Ibid.

The guideline sets out that existing groundwater monitoring programs should be reviewed where an activity is moving from exploration to production.[1051] The EPA may require additional baseline groundwater information if an environmental impact assessment is required under the EPA. Operators must liaise with public water service providers if their activities are carried out in a PDWSA, within 5 km of a PDWSA, or within 5km of a public water bore.[1052] If the activity is within 5km of a bore supplying an Aboriginal community, the relevant public water service provider is the Housing Authority[1053]

4.2.4 South Australia

The PGEA states that the Minister must, in acting in the administration of the Act, take into account the objects of the NRM Act.[1054] An operator that holds an exploration[1055] or production licence[1056] must provide for their water requirements within the framework of the NRM Act, like all other water users. The PGEA sets out that the Minister must have regard to, and seek to further, the objects of the NRM Act.[1057] Under the NRM Act, any water use must be carried out in accordance with the principles set out in the appropriate Regional NRM Plan[1058] and Water Allocation Plan (WAP).[1059] A WAP sets out the rules for managing, taking and using prescribed water. They offer security and equity to water users while balancing the capacity of a region's overall resources and the needs of the environment.[1060]

Water licences are granted for prescribed resources[1061] including source water for hydraulic fracturing operations.[1062] The issuing of permits to drill water wells is also regulated under this

[1051] Ibid.
[1052] Id at 8.
[1053] Ibid.
[1054] *Petroleum and Geothermal Energy Act 2000* (SA), s 6A
[1055] *Petroleum and Geothermal Energy Act* 2000 (SA), s 21(1)
[1056] *Petroleum and Geothermal Energy Act* 2000 (SA), s 34
[1057] *Petroleum and Geothermal Energy Act 2000* (SA), s 95
[1058] *Natural Resource Management Act 2004* (SA), s 75
[1059] *Natural Resource Management Act 2004* (SA), s 76
[1060] Ibid.
[1061] *Natural Resources Management Act 2004* (SA), s 146(1)
[1062] Department of Environment and Water, Unconventional Gas mining planning in the South East What are the roles of Government bodies in this issue?, (accessed 15 June 2017) at http://www.environment.sa.gov.au/Home/Search_Results?dlv_Site%20Wide%20Search%20Results=(keyword=shale%20gas)

legislation.[1063] Well approval is given under the petroleum and geothermal energy legislation.[1064] The NRMA administers authorisations,[1065] issues access entitlements,[1066] allocations[1067] (licensing),[1068] water transfers,[1069] works, site use approvals and compliance activities.[1070] The granting of a water licence covers prescribed watercourses, lakes, wells or surface water.[1071] A water licence provides an operator with an entitlement (water access entitlement) to gain access to a share of water available in consumptive pools.[1072] An operator who has lawful access to water may take it for any purpose.[1073] The occupier of land is entitled to take surface water for any purpose.[1074]

The grant of a water licence under the NRMA includes source water for hydraulic fracturing operations. The issuing of permits to drill water wells is also regulated under the NRMA. Well approval is given under the PGEA. The NRMA administers authorisations, issues access entitlements, allocations (licensing), water transfers, works, site use approvals and compliance activities. Permits to construct repair or backfill wells are administered by the DEWNR on behalf of the Minister. The granting of a water licence covers prescribed watercourses, lakes, wells or surface water. A water licence provides an operator with an entitlement (water access entitlement) to gain access to a share of water available in consumptive pools. An operator who has lawful access to water may take it for any purpose. The occupier of land is entitled to take surface water for any purpose.

The Cooper Basin Petroleum Productions Operations, Statement of Environmental Objectives sets out that wastewater disposal is undertaken in accordance with the *Public Health (Wastewater) Regulations 2013* (SA) which requires that the disposal system is managed in

[1063] *Natural Resources Management Act 2004* (SA), s 139
[1064] *Petroleum and Geothermal Energy Act 2000* (SA), s 10(d)
[1065] *Natural Resources Management Act 2004* (SA), s 226
[1066] *Natural Resources Management Act 2004* (SA), s 146(2)
[1067] *Natural Resources Management Act 2004* (SA), s 152
[1068] *Natural Resources Management Act 2004* (SA), s 146
[1069] *Natural Resources Management Act 2004* (SA), s 150
[1070] Department of Environment and Water, Unconventional Gas mining planning in the South East What are the roles of Government bodies in this issue?, (accessed 18 June 2017) at http://www.environment.sa.gov.au/Home/Search_Results?dlv_Site%20Wide%20Search%20Results=(keyword=shale%20gas)
[1071] *Natural Resources Management Act 2004* (SA), s 146(1)
[1072] Ibid s 146(2)
[1073] *Natural Resources Management Act 2004* (SA), s 124(1)
[1074] *Natural Resources Management Act 2004* (SA), s 124(2)

accordance with the *Environment Protection (Water Quality) Policy 2015*.[1075] Any impacts that result from produced formation water treatment and disposal, and restricting it to defined areas, is reduced by adhering to the requirements of the *Environment Protection Act 1993* (SA), *Environment Protection (Water Quality) Policy 2015*, relevant conditions of any EPA Authorisations and the NRMA. To reduce land contamination and avoid water contamination, the location, design and operation of facilities is consistent with the requirements of the *Environment Protection (Water Quality) Policy 2015*.

4.2.5 Colorado

Access to water in Colorado is based on the 'prior appropriation system'.[1076] The doctrine is embedded in jurisprudence, through constitutional and statutory provisions, and by a line of judicial decisions.[1077] The right to appropriate water for a beneficial use is well established.[1078] An appropriation is best described as the intent to take water accompanied by a physical demonstration of intent.[1079] The system controls who uses water, how much water they use, the types of uses allowed, and when that water can be used.[1080] The first person to appropriate and use water has the first right to use the water within a particular stream system. The person then becomes the senior water right holder on the stream, and that water right must be satisfied before any other water rights can be fulfilled.[1081] The Constitution provides that water of any natural stream not already appropriated is declared to be the property of the public, and dedicated to the use of the people of the State, subject to appropriation.[1082] When this abovementioned water is not adequate for the service of those desiring to use it, those using the water for domestic purposes have preference over those claiming for any other purpose,

[1075] Beach Energy, Statement of Environmental Objectives, Cooper Basin Petroleum Production Operations, (accessed 12 May 2017) pg 15, http://www.beachenergy.com.au/irm/company/showpage.aspx?CategoryId=190&CPID=6631&InstanceVersionNumber=0
[1076] Colorado Division of Water Resources, Department of Natural Resources, Prior Appropriation Law at http://water.state.co.us/surfacewater/swrights/pages/priorapprop.aspx
[1077] *Comstock v. Larimer Weld Reservoir Co*., 58 Colo. 186, 145 P. 700, 1916A Ann. Cas. 416(1914)
[1078] *Metro. Sub. Water Users Ass'n v. Colo. River Water Conservation Dist*., 148 Colo. 173, 365 P.2d 273 (1961)
[1079] *Elk-Rifle Water Co. v. Templeton*, 173 Colo. 438, 484 P.2d 1211 (1971)
[1080] Colorado Division of Water Resources, Department of Natural Resources, Prior Appropriation Law at http://water.state.co.us/surfacewater/swrights/pages/priorapprop.aspx
[1081] Ibid.
[1082] Constitution of Colorado (1876) ss 5 and 6 of Article XVI

and those using the water for agricultural purposes have preference over those using it for manufacturing.[1083]

The GWMA affirms, with respect to the designated ground waters, the long-established policy requiring that water resources be dedicated to beneficial use in reasonable amounts through appropriation.[1084] All designated ground waters in Colorado are declared to be subject to appropriation.[1085] The State's water legislation deals with applications for groundwater, public notices, conditional permits, hearing on objections and well permits.[1086] An operator who wishes to appropriate groundwater for a beneficial use in a designated groundwater basin must apply to the Ground Water Commission (GWC), specifying the exact basin or subdivision from which water is intended to be appropriated.[1087] The application must include, amongst other things, an outline of the beneficial use to which it is intended to use the water, the location of the planned well, the projected average annual amount of water applied for in acre-feet, the projected maximum pumping rate in gallons per minute.[1088] The water that is subject to the application can only be used on the land named in the application.[1089]

An application for an initial appropriation of ground water, even if not within the definition of designated ground water, in a designated ground water basin must be directed to the GWC.[1090] An application that is granted positive consideration by the GWC is published within thirty days.[1091] If an objection is filed the GWC, a date will be set for a hearing. After the hearing if it appears that there are no 'unappropriated waters in the designated source or that the proposed appropriation would unreasonably impair existing water rights from such source or would create unreasonable waste, the application shall be denied; otherwise, it shall be granted.'[1092]

[1083] Colorado Division of Water Resources, Synopsis of Colorado Water Law, (accessed 1 May 2017) at < https://openei.org/wiki/Colorado_Division_of_Water_Resources,_Synopsis_of_Colorado_Water_Law>
[1084] *Ground Water Management Act* (Colorado), § 37-90-102
[1085] *Ground Water Management Act* (Colorado), § 37-90-102(1)
[1086] *Ground Water Management Act* (Colorado), § 37-90-107
[1087] *Ground Water Management Act* (Colorado), § 37-90-107(1)
[1088] *Ground Water Management Act* (Colorado), § 37-90-107(1)
[1089] *Ground Water Management Act* (Colorado), § 37-90-107(1)
[1090] *State ex rel. Danielson v. Vickroy*, 627 P.2d 752 (Colo. 1981)
[1091] *Ground Water Management Act* (Colorado), § 37-90-107(2)
[1092] *Ground Water Management Act* (Colorado), § 37-90-107(4)

The GWC must consider appropriative intent in considering an application for appropriating designated ground water[1093] and is authorised to reject an application if it finds that the intended appropriation will unduly harm existing water rights from the same source, or will create unreasonable waste.[1094]

Subsequent to conditional permits to appropriate designated groundwater, an applicant, within one year from the date of the issuance of the permit, must construct the well or other works necessary to apply the water to a beneficial use.[1095] Once the well is constructed, the applicant must advise the GWC as to the depth of the well, the water-bearing formations intercepted by the well and the maximum sustained pumping rate in gallons per minute.[1096]A final permit is essential to the legislative scheme for the administration of ground water rights.[1097]

Colorado's surface water is protected by the utilisation of internal, intermediate, and external buffer areas.[1098] The rules safeguard surface public water sources by compelling additional protections when gas facilities are planned within a half-mile (804.672 metres) of a designated surface water source and by preventing gas facilities being located within 350 feet (106.68 metres) from designated water sources.[1099] In Colorado, wells and production facilities must not be located within 500 feet of buildings and 1000 feet (304.8 metres) from those with high occupancy.[1100]

Operators must carry out preliminary baseline sampling and subsequent monitoring of all available water sources (up to a maximum of four) within a one-half mile (1.6 km) radius of a

[1093] *Jaeger v. Colo. Ground Water Comm'n*, 746 P.2d 515 (Colo. 1987)
[1094] *Fundingsland v. Colo. Ground Water Comm'n*, 171 Colo. 487, 468 P.2d 835 (1970)
[1095] *Ground Water Management Act* (Colorado), s 37-90-108(1)(a)
[1096] *Ground Water Management Act* (Colorado), s 37-90-108(1)(b)
[1097] *Thompson v. Colo. Ground Water Comm'n*, 194 Colo. 489, 575 P.2d 372 (1978)
[1098] COGCC rule 317B.b at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1099] COGCC rule 317B at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1100] COGCC rule 604(2) at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

proposed gas well, multi-well site, or dedicated injection well.[1101] Subsequent sampling must be conducted at the initial sample locations between six and twelve months, and a second subsequent sampling event shall be conducted between 60 and 72 months following completion of the well or dedicated injection well, or the last well on a multi-well site.[1102]

Colorado's protection of water extends to floodplains, and through obligations to report spills and releases.[1103] This protection is diminished when it comes to existing gas well sites earmarked for expansion (the COGCC grandfathers existing well pads that were in place before 2008).[1104] The standards for groundwater and site-specific water quality classifications are accepted by Colorado's Water Quality Control Commission.[1105] The COGCC adopted a rule requiring baseline and post-completion groundwater monitoring in 2012.[1106] Colorado has comprehensive rules in relation to cement bond logs[1107], mechanical integrity tests[1108], and bradenhead tests,[1109] which are all important elements for securing the integrity of wells.[1110] Baseline water sampling is not uniform across the State of Colorado. For example, the Greater

[1101] COGCC rule 609(b) at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1102] COGCC rule 609(d)(3)B at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1103] COGCC rule 906 at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1104] University of Colorado at Boulder, Protecting Source Water in Colorado During Oil and Gas Development, August 2016, iii at <http://www.oilandgasbmps.org/docs/CO186_ProtectingSourceWaterAugust2016.pdf>
[1105] Water Quality Control Commission at https://www.colorado.gov/pacific/cdphe/wqcc
[1106] COGCC rule 609 at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1107] COGCC rule 317.p at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1108] COGCC rule 316B at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1109] COGCC rule 314 at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1110] COGCC rule 308A.b at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

Wattenberg Area, the location where most gas production occurs in Colorado has a more restricted groundwater monitoring regime.[1111]

Colorado has wide-ranging groundwater quality protection rules administered by the COGCC, such as obligations to carry out baseline water testing[1112] and rules governing drilling[1113] (for example, well casing and cementing). The COGCC rules include restrictive groundwater monitoring regulations[1114] and the requirement for baseline and post line testing of gas wells.[1115] Colorado has restrictive stormwater rules applicable to shale and tight gas activities and a complex system of water rights laws.[1116] The Intermountain Oil and Gas BMP Project's best management practices and database for shale and tight gas development contain mandatory and voluntary best management practices.[1117] The *Water Quality Control Act* (Colorado) has a role in regulating the environmental impacts of shale and tight gas development.

In Colorado, operators must not discharge pollutants into State water without a permit from the water quality control division.[1118] The *Water Quality Control Act* (Colorado) includes provisions for oversight and enforcement of permits for point source discharges and for reporting of non-permitted discharges.[1119] Neither the act nor the regulations requires specific compliance or enforcement responses for point source discharges that occur without a permit

[1111] COGCC rule 318A.f at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1112] COGCC rule 908(9)(A) at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1113] COGCC rule 317e at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1114] Stephanie Neitzel, P.E. Esq. Principal WaterRich Advisors LLC, Centennial, Colorado, Water Quality Regulations for Unconventional Gas Production, United States and Australia Comparison (accessed 17 June 2017) pg 4 at < http://www.awa.asn.au/documents/136%20SNeitzel.pdf>
[1115] Ibid.
[1116] Id at 5.
[1117] The University of Colorado, Getches-Wilkinson Centre for Natural Resources, Energy, and the Environment hosts a website of best management practices, (accessed 12 June 2017) at < http://www.oilandgasbmps.org/>
[1118] Water Quality Control Division, Implementation Policy, Reporting of Surface Water Discharge Associated with Residential and Landscape Irrigation, Colorado Department of Public Health and Environment, [DATE] https://www.colorado.gov/pacific/sites/default/files/WQCD_Irrigation_Discharge_Policy_151208_signed.pdf
[1119] Ibid.

or for failure to report a non-permitted discharge.[1120] These are covered within policies and procedures.[1121]

4.2.6 Conclusion

The author cautiously supports the DoWER and DMIRS administrative agreement which is intended to boost co-operation in relation to the consideration of potential impacts on water resources by activities regulated under the PGERA. It is unsatisfactory that although the DoWER regulates the construction and operation of above ground facilities following gas extraction from below the ground it does not regulate the extraction of gas that occurs below the ground which includes the construction and installation of gas wells, and the operation of hydraulic fracture stimulation processes.

The Western Australian guideline for groundwater monitoring is a useful document and the author favours the case-by-case monitoring approach which is determined subject to the scale and type of operation, level of risk and sensitivity and values of the environment.[1122] The author supports the water protection guideline that sets out that operators must liaise with public water service providers in particular circumstances i.e., where activities are carried out in a PDWSA, within 5 km of a PDWSA, or within 5 km of a public water bore.[1123]

The author favours South Australia's *Environment Protection (Water Quality) Policy 2015* that covers the management of wastewater disposal systems and produced formation water disposal. The *Environment Protection (Water Quality) Policy 2015* also deals with land contamination and water contamination through location, design and operation of facilities.

The author supports Colorado's surface water protection mechanism i.e., the use of internal, intermediate, and external buffer areas. The COGCC rules safeguard surface public water sources by compelling additional protections when gas facilities are planned within a specified

[1120] Ibid.
[1121] Ibid.
[1122] Department Mines and Petroleum and Department of Water, (WA), Guideline for Groundwater Monitoring in the Onshore Petroleum and Geothermal Industry, July 2016, pg 5, http://www.water.wa.gov.au/__data/assets/pdf_file/0019/8812/164265_Groundwater-Monitoring_Guideline.pdf
[1123] Id at 8.

distance from a designated surface water source. Wells and production facilities must not be located within a specified distance building, particularly those with high occupancy.

Preliminary baseline sampling and subsequent monitoring of all available water sources within a specified distance should be mandatory for any shale and tight gas operations. Subsequent sampling should be carried out at initial sample locations between six and twelve months, and subsequent sampling thereafter.

Baseline water sampling is not uniform across the state of Colorado. For example, the Greater Wattenberg Area, the location where most gas production occurs in Colorado has a more restricted groundwater monitoring regime. Colorado's wide-ranging groundwater quality protection rules administered by the COGCC are supported by the author. These include obligations to undertake baseline water testing. .

4.3 Drilling and fracturing

The COGCC actively encourages and promotes waste minimisation by allowing operators to submit management plans to the COGCC that deal with beneficial use, reuse and recycling. The DMIRS and DPC should do the same. This thesis favours the COGCC underground injection authorisation regime over that which is fairly non-existent in Western Australia and South Australia. The process in Colorado appears logically based. An operator must not dispose of water underground or commence construction of a well for the purpose of underground injection without having first received written authorisation from the COGCC. They must submit several application forms along with a service and filing fee. The COGCC may refuse to issue a permit and approve underground injection if it considers that the disposal well could result in a significant adverse impact on the environment.

4.3.1 Flow-back, produced water, recycling and reuse

Flow-back and produced water are the two main sources of waste that require management during gas production.[1124] In the United States, flow-back water management options are extensive and include direct reuse without treatment; on-site treatment and reuse; off-site treatment and reuse; and off-site treatment and disposal. Direct reuse incurs minimal cost, on-site treatment reconditions the water at a moderate cost, off-site treatment and reuse incurs high transportation costs while off-site treatment and disposal incurs high transportation and disposal costs.[1125]

The DMIRS suggests that fracking fluid can be recovered at rates of 40 per cent to 70 per cent and reused in further hydraulic fracturing stimulation programs.[1126] The DMIRS has indicated it would advocate for the treatment and re-use of water on multiple well sites should hydraulic fracturing occur in the future on multiple wells.[1127]

According to ACOLA, during production and initial flow back, 30 per cent to 70 per cent of water injected during fracking is recovered.[1128] Some have reported that up to 50 per cent of the fracturing compounds may remain trapped underground.[1129] In 2014, Buru expected that up to 99 per cent of the water that flowed back from a well would be returned to the formation at the end of production.[1130] Buru aimed to achieve 100 per cent recycling by 2015.[1131]

[1124] American Fuel & Petrochemical Manufacturers, Shale Oil & Gas Production – Water Reuse, Treatment and Disposal, (accessed 28 June 2017) pg 1 at <https://www.afpm.org/shale_development/>

[1125] Pam Boschee, Produced and Flowback Water Recycling and Reuse, 2014 at http://www.halliburton.com/public/multichem/contents/Papers_and_Articles/web/Feb-2014-Oil-Gas-Facilities-Article.pdf

[1126] Department of Mines and Petroleum, Guide to the Regulatory Framework for April 2015 Shale and Tight Gas in Western Australia A Whole-of-Government Approach, 2015 Edition, pg 12 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf

[1127] Department of Mines and Petroleum, 'Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas', Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Department of Mines and Petroleum, 2013, p 15

[1128] Frogtech, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013, pg 28 at http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf

[1129] Earthworks, 'Frack Fluids: Injected and Left Behind' (Fact Sheet), [accessed 1 May 2017] at http://earthworksaction.org/files/publications/FS_LeftBehind_lowres.pdf

[1130] Buru Energy, Buru Energy's proposed gas developments in the Canning Basin, Questions and Answers, March 2014, pg 20 at <http://www.buruenergy.com/wp-content/uploads/Proposed-Gas-Developments-QA.pdf>

[1131] Ibid.

In certain parts of Colorado:

> an estimated 20-30% of the fracking fluid used flows back to the surface as return flows; the majority of the water is permanently lost and removed from the hydrological cycle.[1132]

When the chemical composition of the water coming from the well is similar to the rock formation rather than the fracking fluid, it is classified as produced water and can continue to flow as long as a well is in operation.[1133] Flow-back is a mixture of fracking fluid and formation water (i.e., water rich in brine from the targeted shale gas-rich rock).[1134]

Produced water is naturally occurring water found in shale formations that flows to the surface during the entire life of a gas well.[1135] It has high concentrations of total dissolved solids and leaches out barium, calcium, iron and magnesium and also contains dissolved hydrocarbons such as methane, ethane and propane along with naturally occurring radioactive materials (NORM), for example radium isotopes.[1136] Managing and disposing of water after hydraulic fracturing is challenging given the fluid that returns to the surface within the first seven to 14 days frequently requires treatment for beneficial reuse and/or recycling or be disposed of by injection.[1137]

Recycling and/or reuse should be contextualised more broadly in terms of overall water use and how operators might gain access to water in accordance with the general water resources law.

[1132] Matt Sura, Colorado's Landowner's Guide to Oil and Gas Development, Waste Storage and Disposal (Pits, Injection), (accessed 27 June 2017) at <http://www.oilandgasbmps.org/landowners-guide/>
[1133] Bill Chameides, Fracking Water: It's Just So Hard to Clean, Huff Post, 10 October 2013 at < https://www.huffingtonpost.com/bill-chameides/fracking-water-its-just-s_b_4045936.html>
[1134] Ibid.
[1135] The Institute for Energy and Environmental Research for Northeastern Pennsylvania, What is flowback, and how does it differ from produced water?, (accessed 12 June 2017) at http://energy.wilkes.edu/pages/205.asp
[1136] Ibid.
[1137] American Petroleum Institute, Water Management Associated with Hydraulic Fracturing, API Guidance Document, Hydraulic Fracturing 2, First Edition, June 2010, pg 5 at < https://www.browntechnical.org/products/api-guidance-document-hf2-water-management-associated-with-hydraulic-fracturing.html>

4.3.1.1 Western Australia and South Australia

The Standing Committee on Environment and Public Affairs recommended that operators should be encouraged to explore the recycling of wastewater during hydraulic fracturing operations, where practicable.[1138] In response to the Committee, the government stated that agencies will continue to encourage the recycling of wastewater in accordance with existing policies.[1139]

The recycling of drilling and hydraulic fluids is yet to occur in Western Australia since fracture stimulations have only occurred on single, exploration well sites.[1140] The recycling of produced water depends on the quality and quantity of the water, the local options for alternate uses, and the possibility of reusing the water for future uses.[1141] According to the DoWER, there is limited demand for recycled water due in part to the cost of treatment and distribution which is the main obstacle that restricts development of recycled water schemes across Western Australia.[1142]

It is likely that the same obstacles would apply to the opportunities for reusing produced water for purposes other than hydraulic fracturing.[1143] The recycling of produced water depends on the quality and quantity of the water, the local options for alternate uses, and the possibility of reusing the water for future uses.[1144]

[1138] Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Report 42, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015 at <http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf>

[1139] Government response to Report 42, Standing Committee on Environment and Public Affairs, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, (2016) at < http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/3913895c7a06d337d5c9ab7048257f79000e5c77/$file/tp-3895.pdf>

[1140] Department of Mines and Petroleum, Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, October 2013, pg 15 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf>

[1141] Department of Water, Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the implications for Western Australia of hydraulic fracturing for unconventional gas, (October 2013), pg 11 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/674CC1E61A44E62048257C400011A4E3/$file/ev.fra.131009.sub.115.department+of+water.pdf>

[1142] Ibid.

[1143] Ibid.

[1144] Ibid.

4.3.1.2 Colorado

To encourage and promote waste minimisation in Colorado, operators can voluntarily submit management plans to the COGCC that deal with beneficial use, reuse and recycling.[1145] These plans must describe the type(s) of waste; the proposed use of the waste; method of waste treatment; product quality assurance; and include a copy of any certification or authorisation that may be required by other laws and regulations.[1146]

In line with the American Petroleum Institute (API), operators must undertake significant planning and have knowledge of the chemical additives they are using in fracking operations and a general idea of the composition of flow back and produced water.[1147] Operators have an obligation to select compatible additives and focus their efforts on using environmentally benign ingredients that do not inhibit water treatment initiatives.[1148] Under API guidance, operators must select additives wisely so they enhance the quantity of the fluids that return to the surface providing more options for recycling and/or reuse and/or disposal.[1149] There are well-developed water treatment services available to operators in the United States enabling the conservation of freshwater and the recycling of produced and hydraulic fracturing flowback water.

In many states in the United States, recycling is mandated as a standard in legislation and many have separate commercial and non-commercial operations, whilst some operators treat water recycling like solid waste recycling. The recycling and/or reuse of waste water is vital to gas development.[1150] It is normal for flow-back water to be treated and reused in additional drilling

[1145] COGCC rule 907 a.(3), Management of E&P Waste, Reuse and Recycling at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1146] Ibid.
[1147] American Petroleum Institute, Water Management Associated with Hydraulic Fracturing, API Guidance Document, Hydraulic Fracturing 2, First Edition, June 2010, pg 5 at < https://www.browntechnical.org/products/api-guidance-document-hf2-water-management-associated-with-hydraulic-fracturing.html>
[1148] Ibid.
[1149] Ibid.
[1150] Ibid.

and hydraulic fracturing operations in the United States especially on sites where there are multiple wells.[1151]

In some states, the recycling of flow-back is not prohibited but not typically done due to the small size of operations and associated transportation costs.[1152] In the United Kingdom, the method for disposal can be on-site treatment with re-use of water and disposal of remaining liquids and solids to a suitable licensed waste treatment and disposal facility; removal off site to a suitable licensed waste treatment and disposal facility and disposal to a special sewer with the permission of the relevant waste water utility company.[1153]

Some parts of the United States encourage operators to use alternative sources of water and recycle waste fluids for hydraulic fracturing.[1154] They use their own waste fluids, which include produced water and flow-back for frac supply purposes. There are specific protocols for off-site waste fluid treatment and reclamation for frac water supply purposes.[1155] Produced water may be transferred offsite for use in hydraulic fracturing at other wells.[1156] Some states occasionally spread produced water on roads for dust and ice control at the request of local authorities, although flow-back fluids from hydraulic fracturing may not be spread on roads.[1157] In the United States, states are urged to encourage operators to develop and have the adequate capacity and infrastructure to manage hydraulic fracturing fluids/wastes, including transportation, recycling, treatment and disposal.[1158]

In terms of whether this is a practical proposition given distances and transport costs over large distance there are certainly options available. Flow-back water is the water that comes to the

[1151] Department of Mines and Petroleum, Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, October 2013, pg 15 at <http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf>

[1152] Department of Natural Resources, Ohio Hydraulic Fracturing State Review, January 2011 at < https://oilandgas.ohiodnr.gov/portals/oilgas/pdf/stronger_review11.pdf>

[1153] Department of Energy & Climate Change, (United Kingdom), Fracking UK shale: water, February 2014

[1154] Department of Natural Resources, Louisiana Hydraulic Fracturing State Review, March 2011 at < http://www.dnr.louisiana.gov/assets/OC/haynesville_shale/071311_stronger_review.pdf>

[1155] Ibid.

[1156] Carlos R. Romo & J. Scott Janoe, Regulatory Regimes for Recycling Produced and Frac Flowback Water, 2012 at <http://ssrn.com/abstract=2124696>

[1157] Department of Natural Resources, Ohio Hydraulic Fracturing State Review, January 2011 at < https://oilandgas.ohiodnr.gov/portals/oilgas/pdf/stronger_review11.pdf>

[1158] Department of Natural Resources, 2014 Stronger Guidelines, 2014 at <http://www.strongerinc.org/stronger-guidelines>

surface after hydraulic fracturing.[1159] Produced water is water trapped in underground formations that returns to the surface along with oil and gas.[1160] Produced formation water refers to water extracted from hydrocarbon reservoirs.[1161] The experience in the United States will be used in order to determine whether the recycling of produced water (to the extent and of the type) as it happens in that jurisdiction is appropriate in Western Australia given the difference in conditions and also whether it is necessary in Western Australia for the shale gas industry. Water that returns to the surface during and after hydraulic fracturing and contains clays, chemical additives, dissolved metal ions and total dissolved solids (TDS).[1162] The majority of flow back returns to the surface in the first seven to 10 days while the remainder occurs over a three to four week period.[1163]

The thesis supports the work undertaken by the University of Colorado's Intermountain Oil and Gas BMP Project.[1164] Best management practices (BMP's) are designed to avoid or reduce impacts caused by shale and tight gas operations to air, water, soil, or biological resources, and to reduce harmful impacts to the environment and wildlife resources.[1165] The Rifle, Silt, New Castle Community Development Plan (RSNC-CDP) was an innovative project and a new scheme for how a community and producers could work together to successfully manage natural gas development. The RSNC-CDP employs responsible development and BMP's.[1166] Under the RSNC-DCP producers agree to provide the public with a semi-annual drilling plan and an update on changes;[1167]

[1159] AGL, Responses to flowback water FAQ's, (accessed 12 June 2017) at http://yoursayagl.com.au/welcome-to-agls-online-community/news_feed/responses-to-flowback-water-faqs

[1160] Produced Water Treatment and Beneficial Use Information Centre, About Produced Water (Produced Water 101), (accessed 12 June 2017) at http://aqwatec.mines.edu/produced_water/intro/pw/

[1161] Department of Mines and Petroleum, (WA), Summary of comments and departmental responses from public consultation for new environment regulations, Petroleum and Geothermal Environment Regulations & Guidelines for Preparation and Submission of an Environment Plan, (accessed 15 June 2017) at http://www.dmp.wa.gov.au/Documents/Petroleum/PD-SBD-NST-115D.pdf

[1162] The Institute for Energy and Environmental Research for Northeastern Pennsylvania, What is flowback, and how does it differ from produced water?, (accessed 12 May 2017) at <http://energy.wilkes.edu/pages/205.asp>

[1163] Ibid.

[1164] Intermountain Oil and Gas BMP Project at http://www.oilandgasbmps.org/

[1165] COGCC rules 100 Series at https://cogcc.state.co.us/documents/reg/Rules/LATEST/100Series.pdf

[1166] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1167] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

Producers agree to transport water in pipelines to centralised facilities rather than by truck.[1168] They agree that wastewater should be transported to disposal injection wells[1169] and not stored other than in temporary storage tanks.[1170] Producers agree that no evaporative pits are to be used in the leased areas.[1171] That there are set-backs from inhabited dwellings of 500 feet whenever possible.[1172] Producers agree that water quality testing of all domestic wells within 1/2 mile of well pad is undertaken before drilling begins.[1173] They agree that water quantity testing is available when requested by the landowner.[1174] Producers agree that all HF operations shall be conducted with 'green frac' methods, utilizing only sand and water as fracing materials or other "green frac" materials.[1175]

4.3.2 Beneficial use

The United States insists that water that returns to the surface should be treated as a resource rather than a waste product.[1176] It can be used for subsequent hydraulic fracturing operations

[1168] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1169] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1170] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1171] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1172] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1173] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1174] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1175] The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

[1176] United States Department of the Interior, Bureau of Reclamation, Oil and Gas Produced Water Management and Beneficial Use in the Western United States, Reclamation, Managing Water in the West, Science and Technology Program Report No. 157, 2011, pg 2 at <https://www.usbr.gov/research/AWT/reportpdfs/report157.pdf>

but also for agricultural purposes, in the community and to benefit the environment.[1177] As a result of the large volumes of produced water generated in the Western United States and the developing need for new water supplies, produced water has the potential to augment conventional water supplies. [1178] Beneficial uses of produced water include livestock watering, crop irrigation, stream flow augmentation (which has the potential to improve stream habitat and increase potable water supply)[1179] and industrial uses.[1180] Produced water can also be deposited in aquifer storage for future use.[1181]

There are significant limitations to the use of produced water for beneficial uses outside of the gas industry, for example there are issues with timing, reliability, limited amounts, and varying water quality and the costs required to treat the water to levels required by the other uses.[1182] The type of beneficial use most suitable for a produced water application is subject to the geographical location of its generation, the location of the beneficial use, and the constituent concentrations in the produced water.[1183]

4.3.3 Well integrity – Western Australia and South Australia

According to Dr Tina Hunter the existing regulatory framework for shale and tight gas activities in Western Australia are best practice though the regulatory standards required for environmental plans judged against those for well integrity displays the major failing of existing regulatory regimes in minimising the environmental impacts of petroleum

[1177] Dr. David R. Stewart, Treatment for Beneficial Use of Produced Water and Hydraulic Fracturing Flowback Water, US EPA Workshop of Wastewater Treatment and Related Modelling for Hydraulic Fracturing, 2013, pg 1 at <https://www.epa.gov/sites/production/files/documents/stewart_0.pdf>

[1178] UNITED STATES Department of the Interior, Bureau of Reclamation, 2011, at http://www.usbr.gov/research/AWT/reportpdfs/report157.pdf

[1179] Plumlee MH, Gurr CJ & Reinhard M, 'Recycled water for stream flow augmentation: benefits, challenges and the presence of wastewater-derived organic compounds' (2012) Nov 1: 438 *Sci Total Environ* 541-8 at <http://www.ncbi.nlm.nih.gov/pubmed/23041295>

[1180] U.S Department of Interior, Bureau of Reclamation, Oil and Gas Produced Water Management and Beneficial Use in the Western United States, Reclamation Managing Water in the West, Science and Technology Program Report No. 157, pg 1 at < https://www.usbr.gov/research/dwpr/reportpdfs/report157.pdf>

[1181] Ibid.

[1182] CDR Associates, for the Colorado Energy Office & Colorado Mesa University Water Center, Produced Water Beneficial Use Dialogue, Opportunities and Challenges for Re-Use of Produced Water on Colorado's Wester Slope, (2014) pg 11 at < http://www.oilandgasbmps.org/viewpub.php?id=634>

[1183] U.S Department of Interior, Bureau of Reclamation, Oil and Gas Produced Water Management and Beneficial Use in the Western United States, Reclamation Managing Water in the West, Science and Technology Program Report No. 157, pg 1 at < https://www.usbr.gov/research/dwpr/reportpdfs/report157.pdf>

[1183] Ibid.

activities.[1184] These shortcomings are not confined to the WA's regulatory framework, but prevalent in most Australian (and international) jurisdictions.[1185] According to Dr Hunter the regulatory framework fails to minimise the impact of petroleum activities, including shale and tight gas activities on the environment.[1186]

In Western Australia, an operator must have an approved WMP for hydraulic fracturing.[1187] A WMP must be appropriate for the well activity; identify risks and set out management regimes.[1188] If an activity relates to the exploration or recovery, the WMP must show that the risks identified will be managed in a manner that is consistent with good oil field practice and will not result in the occurrence of significant risk to which the plan relates.[1189]

WMPs must include specific information, for example they must provide an explanation of the design, construction, operational activity and management of wells.[1190] They must detail the chemicals used for the purposes of horizontal drilling or hydraulic fracturing and the estimated total volume and composition of returned fluids and arrangements for the management of those fluids. [1191] A WMP must be appropriate; identify risks and set out management regimes[1192] and show that identified risks will be managed consistent with good oil-field practice.[1193] A WMP must also list the Australian and international standards that apply in relation to each well activity.[1194]

A WMP must explain the philosophy of, and criteria for, the design, construction, operational activity and management of the well; and the possible production or injection activities of the well, showing that each well activity will be carried out in accordance with sound engineering

[1184] Hunter, T. (2014). Minimising the impact of shale and tight gas projects in Western Australia: an assessment of the existing regulatory framework. *APPEA Journal*, 83-90
[1185] Ibid
[1186] Ibid
[1187] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 10
[1188] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 16
[1189] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 16
[1190] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 17(1) and Schedule 1
[1191] Ibid.
[1192] Id at 16
[1193] Ibid.
[1194] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015*, Schedule 1, Item 14

principles, codes, standards and specifications and, if the activity relates to the exploration for or recovery of petroleum, good oil-field practice.[1195]

A WMP must describe each well activity,[1196] provide details of chemicals and other substances that may be added or introduced in the course of well activity[1197] and a list of the principal Australian and international standards that apply to each well activity and plant used.[1198] An operator is required to control well integrity hazard (WIH) or risk.[1199] These are events that may compromise the integrity of a well, involve a risk of damage to an underground formation that contains gas or an aquifer or any other part of the environment.[1200] An operator must describe how they will identify, monitor, mitigate and deal with a WIH and any increase in an existing risk for the well, including the possibility of continuing a well activity for the purpose of dealing with the WIH or the risk.[1201] An offence is committed if a well is operated and a WIH has been identified or there has been a significant increase in an existing risk for the well.[1202]

FMPs must list the aquifers potentially affected by the development of the gas field and provide a management proposal that includes baseline monitoring of groundwater sources.[1203] They must detail proposals for the enhanced recovery or recycling of petroleum; the processing, storage or disposal of petroleum; the injection of water or treatment material into an underground formation;[1204] arrangements for the management of produced formation material and waste fluid and other waste material produced from wells.[1205]

[1195] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* Schedule 1, Item 4
[1196] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 1, Item 3 – Well management plan
[1197] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* Schedule 1, Item 8
[1198] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* Schedule 1, Item 14
[1199] *Petroleum and Geothermal Energy (Resource Management and Administration) Regulations 2015* (WA), r 33
[1200] *Petroleum and Geothermal Energy (Resource Management and Administration) Regulations 2015* (WA), r 4
[1201] Ibid Schedule 1 r 7.
[1202] Ibid r 33.
[1203] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 8
[1204] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 10
[1205] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 14

Operators must submit daily activity reports that provide a summary of activities that are carried out at the well including, but not limited to, details of chemicals used and stored onsite and how deep the well has been drilled.[1206] A FMP must detail the enhanced recovery or recycling of petroleum; the processing, storage or disposal of petroleum; and the injection of water or treatment material into an underground formation.[1207]

A WIH or risk[1208] can affect well integrity. A WIH can involve a risk of damage to an underground formation that contains gas; or an aquifer or any other part of the environment.[1209] An operator must describe how they will identify, monitor, mitigate and deal with a WIH; and any increase in an existing risk for the well, including the possibility of continuing a well activity for the purpose of dealing with the WIH or the risk.[1210] Western Australia's chemical disclosure obligations require operators to submit drilling fluid particulars as part of their application to drill;[1211] provide fluid information as part of their Well Completion Plan;[1212] and for any approved petroleum activities, a summary of their approved EP, including all chemicals likely to be used, which is publicly disclosed on the DMIRS website.

An operator must not recover gas unless they have an FMP in force or an approval under regulation 59(1) of the *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015,* to recover gas without an approved FMP.[1213] An FMP must detail any aquifers that could be affected by the development of the field and the applicant's proposals for the management of such aquifers including proposals for baseline

[1206] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 5 e
[1207] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 10

[1208] *Petroleum and Geothermal Energy (Resource Management and Administration) Regulations 2015* (WA), r 33
[1209] *Petroleum and Geothermal Energy (Resource Management and Administration) Regulations 2015* (WA), r 4
[1210] Ibid Schedule 1 r 7.
[1211] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 1, Item 8
[1212] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 74 and Schedules 8 and 9
[1213] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 41

monitoring[1214] of groundwater sources, details of the operators proposals for the enhanced recovery or recycling of petroleum, the processing, storage or disposal of petroleum, the injection of water or treatment material into an underground formation[1215] and descriptions of the operators plans for decommissioning and rehabilitation.[1216] Operators must submit daily activity reports that provide a summary of any activity that is carried out at the well including, but not limited to, details of chemicals used and stored onsite and how deep the well has been drilled.[1217]

Wells are designed with layers of steel casing and cement that form a uninterrupted barrier between the well and surrounding rock.[1218] These designs meet pressure, temperature, operational stresses and loads.[1219] In South Australia, wells are pressure tested before hydraulic fracturing and monitoring programs are in place i.e. well logs, pressure measurements, casing integrity measurements and corrosion monitoring programs to determine the condition of casing and cross flow behind casing.[1220] The casing and cement is pressure tested to detect any leaks before further steps are taken in the well construction process.[1221] Evaluation tools are used to assess the cement bond to confirm long term integrity of the well's construction.[1222] The whole process 'is the subject of constant innovation by industry, is heavily regulated…and requires that operators adhere to the highest well design standards, including ongoing monitoring of the integrity of each barrier (casing strings) within the well bore'.[1223]

[1214] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 8
[1215] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 10
[1216] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 16
[1217] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 5
[1218] Energy Resources Division, Department of the Premier and Cabinet, South Australia, Gas and Oil in Unconventional Reservoirs in the South East of South Australia, Version 27/07/17, pg 7 <https://petroluem.statedevelopment.sa.gov.au>
[1219] Id at 5.
[1220] Ibid.
[1221] Id at 7.
[1222] Ibid.
[1223] Ibid.

4.3.3.1 Colorado

The COGCC requires operators to construct wells 'with multiple layers of steel pipe (casing) that are "telescoped" one inside the other, down the hole as it is deepened'.[1224] The COGCC insists that it undertakes pre and post construction wellbore reviews on every well permitted in Colorado.[1225] In Colorado, a pre-construction review of well casing and cement design is carried out to verify that the wellbore will isolate fresh water from hydrocarbons.[1226]

The COGCC carries out field inspections on a number of wells to monitor drilling and completion operations, including hydraulic fracturing.[1227] Following well construction, the COGCC reviews well log data, service reports, and daily field reports to confirm that casings were installed pursuant to approved permits and COGCC rules and policies.[1228]

4.3.4 Underground injection

Underground injection is a fundamental part of hydraulic fracturing and waste water disposal.[1229] It is common practice for flow-back water to be reused in subsequent drilling and hydraulic fracturing operations in the United States.[1230] The recycling of drilling and hydraulic fluids has not occurred in Western Australia to date given it has only been used on single,

[1224] Colorado Oil & Gas Conservation Commission, Department of Natural Resources, Engineering Unit – Well Bore Integrity, [DATE OR DATE VIEWED] at <https://cogcc.state.co.us/documents/about/TF_Summaries/GovTaskForceSummary_Engineering%20Wellbore%20Integrity.pdf>
[1225] Ibid.
[1226] Ibid.
[1227] Ibid.
[1228] Ibid.
[1229] Mark Zoback, Saya Kitasei, Brad Copithorne, Addressing the Environmental Risks for Shale Gas Development, Briefing Paper 1, World Watch Institute, 2010, pg 9 at <https://www.worldwatch.org/files/pdf/Hydraulic%20Fracturing%20Paper.pdf>
[1230] Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, Department of Mines and Petroleum, (2013) ,pg 15 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf

exploration well sites, though the DMIRS strongly advocates the treatment and re-use of water on multiple well sites.[1231]

In the United States, a large amount of the hydraulic fracturing fluid is retrieved and placed in evaporative pits and re-used in other operations or disposed of in surface waters, underground reservoirs, or at treatment facilities.[1232] The fluid comprises water (99 percent), sand and chemical additives.[1233] Managing it correctly is key to protecting the environment when it comes to the production of shale and tight gas.[1234] Produced water has the capacity to supplement conventional water supplies if handled as a resource rather than a waste product.[1235] The disclosure of hydraulic fracturing fluid additives is an important issue which jurisdictions address through legislation to varying degrees.[1236] The treatment and disposal of waste water is a critical issue where hydraulic fracturing is used[1237] and there are different options that should be considered.[1238]

Underground injection and/or re-injection commonly occurs when 'injection zones' are available.[1239] To avoid groundwater degradation in aquifers, reinjection is not permitted.[1240] Reinjecting produced water into gas formations does not pose additional risks to underground aquifers, though reinjection into aquifers may affect groundwater quality.[1241] Produced water

[1231] Ibid.
[1232] James G. Speight, Shale Gas Production Processes, Gulf Professional Publishing, 2013, pg 141
[1233] Energy.Gov, Office of Fossil Energy**,** (United States), Shale Gas 101, 'Aren't shale fracturing fluids toxic?'**,** (accessed 19 June 2017) at https://www.energy.gov/fe/shale-gas-101#faq_7
[1234] Ibid.
[1235] Katie Guerra, Katherine Dahm & Steve Dundorf, Oil and Gas Produced Water Management and Beneficial Use in the Western United States, Science and Technology Program Report No. 157, U.S. Department of the Interior, Bureau of Reclamation, 2011, pg 2 at <https://www.usbr.gov/research/AWT/reportpdfs/report157.pdf>
[1236] Energy.Gov, Office of Fossil Energy, (United States), Shale Gas 101, 'Aren't shale fracturing fluids toxic?', (accessed 19 June 2017) at <https://www.energy.gov/fe/shale-gas-101#faq_7
[1237] World Energy Outlook, Golden Rules for Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas**,** (2012) , pg 32 at http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf
[1238] Id at 33.
[1239] Department of Mines and Petroleum, Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Parliament of Western Australia, 'Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, October 2013, pg 15 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf
[1240] Ibid.
[1241] Standing Committee on Environment and Public Affairs, Parliament of Western Australia Report 42, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, pg 125 at <http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf>

must be treated prior to injection if it is not of the same quality as the aquifer to ensure that its water quality is not compromised.[1242] There must be a porous and permeable formation capable of receiving injected fluids in close proximity to the gas field.[1243]

Where local sites are not available, waste water in the United States is often transported to other locations or treated through either self-contained systems at well sites or fields, or through community waste water treatment plants or commercial treatment facilities.[1244] An operator's ability to transport waste to treatment plants may be restricted to large urban centres with treatment plants with limited capacity.[1245] Underground injection and transportation to treatment facilities may or may not be practical[1246]

Generally speaking, there is little risk of fracking chemicals and produced water contaminating aquifers[1247] given that gas tends to be well below the depth of potable aquifers and that shales act as aquitards[1248] (a zone that restricts the flow of groundwater). Potential contamination can result from well failure, stimulating fractures/faults and poor handling of produced water.[1249]

4.3.4.1 Western Australia and South Australia

The DMIRS and DoWER regulate hydraulic fracture wastewater where it is linked to a prescribed premises licensed under the *Environmental Protection Act 1986* (WA). The waste may be disposed of by storing it in evaporation ponds (lined with strong plastic used to hold flowback fluids or produced formation water) or underground by injecting into deep porous rock formations.[1250]

[1242] Ibid

[1243] J. Daniel Arthur, Bruce Langhus, David Alleman, ALL Consulting, An Overview of Modern Shale Gas Development in the United States, 2008, pg 21 at <http://www.all-llc.com/publicdownloads/ALLShaleOverviewFINAL.pdf>

[1244] Ibid.

[1245] Ibid.

[1246] Ibid.

[1247] Australian Council of Learned Academies, Potential Geological Risks Associated with Shale Gas Production in Australia, January 2013, pg 4 at <http://www.acola.org.au/PDF/SAF06FINAL/Frogtech_Shale_Gas_Geology_and_Risks%20Jan2013.pdf>

[1248] Ibid.

[1249] Ibid.

[1250] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Government Approach, 2015 Edition, pg 31, http://www.dmp.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf

The disposal method must be set out in an operator's EP and submitted to the DMIRS before commencement of any petroleum activities. The DoWER ensures safe disposal by licencing carriers, drivers and vehicles involved in public road transportation under the *Environmental Protection (Controlled Waste) Regulations 2004* (WA). DMIRS regulates the injection or re-injection through the *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA).

Where an activity involves the injection or re-injection of produced formation water into wells in Western Australia, the EP implementation strategy must specify the maximum permissible concentration of petroleum in the water.[1251] An operator must ensure that the concentration of petroleum in any produced formation water does not exceed the specified concentration.[1252] The Minister must not give consent unless the operator demonstrates, to the satisfaction of the Minister, that the proposed discharge, injection or re-injection will not result in the occurrence of any significant new environmental impact or environmental risk, or a significant increase in any existing environmental impact or environmental risk.[1253] A geothermal energy recovery development plan must detail the enhanced recovery or recycling of produced formation material; the processing, storage or disposal of produced formation material; and the injection of water or treatment material into an underground formation.[1254] Proposals must detail how waste water will be treated, reused and disposed of[1255] and operators are encouraged to reuse fracking fluid where possible.[1256]

A petroleum production licence in South Australia authorises an operator to carry out injection.[1257] An operator who drills a well must assess the geology through which the well passes, and the prospect of gas for which the licence is held in accordance with good industry

[1251] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA), r 15(8)
[1252] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA), r 33(1)
[1253] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA), r 33(5)
[1254] Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 (WA), Schedule 4, Item 10
[1255] Department of Mines, Industry Regulation and Safety, Natural Gas from Shale and Tight Rocks An overview of Western Australia's regulatory framework February 2014, pg 8 at http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-NST-102D.pdf
[1256] Ibid.
[1257] *Petroleum and Geothermal Energy Act* (SA), *s* 34(2)(a)(i)

practice and in accordance with the *Petroleum and Geothermal Energy Regulations 2013* (SA).[1258]

An operator must provide a daily drilling report which includes information on operations carried out during the reporting period, a description of the formations, and the depth of any geological formation tops encountered during the reporting period and also well logs acquired during the reporting period.[1259] If an operator undertakes drilling they must provide a well completion report.[1260]

4.3.5 Chemical disclosure

Around 23 states in the United States, including Colorado, use FracFocus to publicly disclose[1261] the composition of hydraulic fracturing fluids, including the chemicals used.[1262] FracFocus is a web-based register managed by the Ground Water Protection Council[1263] and the Interstate Oil and Gas Compact Commission[1264] that provides information on hydraulic fracturing fluid products, including trade name, supplier, purpose and composition.[1265]

Services providers and vendors in Colorado who provide hydraulic fracturing additives must provide an operator with the total volume of water used in the hydraulic fracturing treatment of the well or the type and total volume of the base fluid used in the hydraulic fracturing treatment, if something other than water; each hydraulic fracturing additive used in the hydraulic fracturing fluid and the trade name, vendor, and a brief descriptor of the intended use or function of each hydraulic fracturing additive in the hydraulic fracturing fluid; each chemical intentionally added to the base fluid; the maximum concentration, in percent by mass, of each

[1258] *Petroleum and Geothermal Energy Regulations 2013* (SA), s 27
[1259] *Petroleum and Geothermal Energy Regulations 2013* (SA), s 38(3)
[1260] *Petroleum and Geothermal Energy Regulations 2013* (SA), s 40
[1261] Chemical Disclosure Registry, Colorado Rules and Regulations, Definitions 100 Series, pg 100-2, 2016 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/CompleteRules%20as%20of%20March%2016,%202016.pdf
[1262] Frac Focus Chemical Disclosure Registry, (accessed 18 June 2017) at <http://fracfocus.org/>
[1263] Groundwater Protection Council, (accessed (accessed 19 June 2017) at <http://www.gwpc.org/>
[1264] Interstate Oil & Gas Compact Commission, (accessed 19 June 2017) at <http://iogcc.publishpath.com/>
[1265] Frac Focus Chemical Disclosure Registry, (accessed 18 June 2017) at <http://fracfocus.org/>

chemical intentionally added to the base fluid; and the chemical abstract service number for each chemical intentionally added to the base fluid, if applicable.[1266]

Western Australia has a 'system-based' chemical disclosure approach that sanctions public disclosure of chemicals while providing protection of manufacturer's products.[1267] In Western Australia, a WMP must include details of chemicals and other substances that may be — (a) in, or added to, treatment materials to be used for the purposes of drilling or hydraulic fracturing undertaken in the course of each well activity; or (b) otherwise introduced into a well or underground formation in the course of each well activity; or (c) otherwise used in the course of each well activity.[1268] Daily well activity reports must provide details of chemicals or other substances kept on site for use in the well activity.[1269]

The disclosure of chemicals in Western Australia is to the DMIRS, not to the public, which facilitates disclosure without compromising commercially sensitive information about product recipes.[1270] The information must also be submitted to the DMIRS as part of the summary EP, which is then made publicly available.[1271] This thesis provides guarded support to Western Australia's chemical disclosure obligations which require operators to submit information to the DMIRS. Western Australia's system sanctions public disclosure while protecting manufacturers. The disclosure is to the DMIRS not directly to the public.

The COGCC requires operators to maintain a chemical inventory, disclose certain information and take precautions to keep wells under control. This thesis favours Colorado's chemical

[1266] COGCC rules 205A.b.(2)(A)(viii) – (xii) s

[1267] Letter from Hon Bill Marmion MLA, Minister for Mines and Petroleum, 14 April 2015, p 4 to the Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, pg 87 at <https://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf>

[1268] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 1, Item 8

[1269] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 5, Item 21

[1270] Submission 105 from Department of Mines and Petroleum, to the Standing Committee on Environment and Public Affairs Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, 3 October 2013, pg 11 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdfhttp://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf
The exact chemical recipe for a product is not disclosed, only the chemicals that may be mixed together to form the product (such as drilling muds or fracturing fluids).

[1271] Ibid.

disclosure system where operators complete a simple chemical disclosure registry form and upload it onto the chemical disclosure registry (FracFocus). This thesis favours Colorado's system where operators must submit chemical disclosure forms within 60 days of the conclusion of fracking. An operator who claims that the identity or concentration of a chemical is a trade secret does not need to disclose them on their disclosure form, though the information must be provided to the COGCC if it is requested.

Any information that is posted to the site or sent to the COGCC (unless a trade secret) is public information. The COGCC and the public can search for information by geographic area, ingredient, chemical abstract service number, time period, and operator. The thesis supports Colorado's preliminary baseline sampling and subsequent monitoring where all available water sources within a one-half mile radius of a proposed gas well, multi-well site, or dedicated injection well. Subsequent sampling is carried out at the initial sample locations between six and 12 months, and a second subsequent sampling is conducted between 60 and 72 months following completion of the well or dedicated injection well, or the last well on a multi-well site.[1272]

Regulation 83 provides a definition of permanently confidential information. Regulation 83(4) and 83(5) set out the circumstances where documentary information given by a person to the Minister is considered to be permanently confidential information. For example, information is considered permanently confidential if, when it was given the Minister was advised in writing that the person classified the information as a trade secret; or information the disclosure of which would, or could reasonably be expected to, adversely affect the person's business, commercial or financial affairs and the Minister did not give the person a written notice.

This thesis supports the deletion of regulation 83 of the *Petroleum* and *Geothermal Energy Resources (Resource Management and Administration) Regulations 2015*, as recommended by the Standing Committee on Environment and Public Affairs. The Standing Committee on Environment and Public Affairs determined that regulation 83 does not, in their opinion, meet

[1272] COGCC rule 609 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

the DMIRS's stated intention of transparency in relation hydraulic fracturing and the public.[1273] The Committee recommended that regulation 83 be amended and, specifically, that regulations 83(4) and 83(5) be deleted.[1274]

Halliburton Australia, who support disclosure to FracFocus, recently suggested two alternatives to full public disclosure, namely i) a procedure that disclosures hydraulic fracturing ingredients and maximum concentrations on a well-by-well basis; or ii) disclosure to the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) with patented information protected from public release.[1275]

Santos Limited, who supports FracFocus disclosure, deem that full disclosure of certain chemicals should be protected given that full disclosure may curtail the use of new, innovative and environmentally benign products.[1276] AWE Limited is concerned about theDMIRS's Chemical Disclosure Guideline[1277] and deem that disclosure may lead some third-party contractors to withhold their products from the Western Australian hydraulic fracturing market due to sensitivities surrounding the release of chemical compounds.[1278]

Operators must retain appropriate operational records to enable them to make and substantiate reports required by the COGCC.[1279] Operators must submit chemical disclosure forms within

[1273] Report 42, Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, pg 43 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf>

[1274] Ibid.

[1275] Halliburton Australia Pty Ltd, Submission to the Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, 4 October 2013, pp 4-55 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/570201DA298F66B048257C40000F617F/$file/ev.fra.131004.sub.106.halliburton.pdf>

[1276] Santos Limited, Submission to the Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, 4 October 2013, p 10 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/A01ABCA4A181C60C48257C40000FF3A8/$file/ev.fra.131004.sub.109.santos+ltd.pdf>

[1277] Department of Mines, Industry Regulation and Safety (WA), Chemical Disclosure Guideline, 2013 at < http://www.dmp.wa.gov.au/Documents/Environment/ENV-PEB-178.pdf>

[1278] Submission 113 from AWE Limited, Submission to the Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, 7 October 2013, p 25 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/34B73EFE0365812B48257C4000115456/$file/ev.fra.131007.sub.113.awe+limited.pdf>

[1279] COGCC rule 205. a, Access to Records at < https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

60 days of the conclusion of fracking.[1280] An operator who claims that the identity or concentration of a chemical is a trade secret does not need to disclose them on their disclosure form though the information must be provided to the COGCC if it is requested.[1281]

Operators must give at least 48 hours advanced written notice to the COGCC prior to undertaking hydraulic fracturing[1282] and continuously monitor and record well pressure between the intermediate casing and the production casing to ensure that fracking fluids are restricted to the targeted formations.[1283] An operator must notify the COGCC if they observe changes in well pressure and indicate that fluid is leaking from the well.[1284] Operators are required to carry out baseline and post-completion surface water sampling where fracking occurs in a Surface Water Supply Area[1285] and in relation to green well completions[1286] to reduce harmful air emissions.

An operator must not dispose of water underground or commence construction of a well for the purpose of underground injection without having first received written authorisation from the COGCC.[1287] An operator must submit an Underground Injection Formation Permit Application, Form 31[1288] and an Injection Well Permit Application, Form 33.[1289] If an operator intends to drill a disposal well they must also submit (concurrently) an Application for Permit-

[1280] COGCC rule 205A, Hydraulic Fracturing Chemical Disclosure at <https://cogcc.state.co.us/Announcements/Hot_Topics/Hydraulic_Fracturing/Rule205A.pdf>
[1281] Ibid.
[1282] COGCC rule 316C at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1283] COGCC rule 341 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1284] Ibid.
[1285] COGCC rule 317B at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1286] COGCC rule 805 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1287] COGCC rule 325 a.
[1288] COGCC Form 31, Underground Injection Formation Permit Application at <https://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/form31.pdf>
[1289] Form 33, Injection Well Permit Application at <https://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/form33.pdf>

to-Drill, Form 2,[1290] along with a service and filing fee[1291] The COGCC may refuse to issue a permit and approve underground injection if it considers that the disposal well could result in a significant adverse impact on the environment.[1292]

Colorado is at the forefront of gas regulation in the United States given it has, amongst other things, a detailed drilling and well site activities regime and specific environmental regulations to manage water.[1293] In Western Australia, an operator may carry out drilling and injection activities into natural reservoirs to enhance gas production.[1294] The grant of a production licence authorises an operator to undertake injection[1295] and, if they drill a well, they must assess the geology the well passes through and the prospectivity of gas in accordance with good industry practice.[1296]

Operators in Colorado must provide landowners with a notice of intent to carry out hydraulic fracturing.[1297] They must give at least 48 hours advance notice to the COGCC of a hydraulic fracturing treatment.[1298] The COGCC requires operators to maintain a chemical inventory,[1299] disclose certain information[1300] and take precautions to keep wells under control.[1301] The COGCC rules require operators to have well setbacks and take precautions near surface waters

[1290] COGCC Form 2, Application for Permit to: at <https://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/form2_20130806.pdf>
[1291] COGCC rule 325 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1292] COGCC rule 325 b.
[1293] Stephanie Neitzel, P.E. Esq. Principal WaterRich Advisors LLC, Centennial, Colorado, Water Quality Regulations for Unconventional Gas Production, United States and Australia Comparison, pg 4 at < http://www.awa.asn.au/documents/136%20SNeitzel.pdf>
[1294] *Petroleum and Geothermal Energy Act 2000* (SA), s 10(3)(b)(c)
[1295] Section 34(2)(a)(i) of the PGE Act
[1296] *Petroleum and Geothermal Energy Regulations 2013* (SA), r 27
[1297] COGCC rule 305.e.e(1)A at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1298] COGCC rule 316C at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1299] COGCC rule 205 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1300] COGCC rule 205A at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1301] COGCC rule 317 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

used for drinking.[1302] Operators must monitor bradenhead pressure during well stimulation operations.[1303] There are detailed pit permitting and reporting requirements[1304] and pit lining requirements and specifications contained in the COGCC rules.[1305] The COGCC rules require that spills and releases be reported to the COGCC, CDPHE and the landowner.[1306]

An operator must prepare and submit a daily drilling report that specifies, amongst other things, the depth of the well at the end of the reporting period; the operations carried out during the reporting period; resource descriptions; a description of the formations; and the depth of any geological formation tops encountered during the reporting period.[1307] An operator who undertakes drilling must provide a well completion report in accordance with the requirements of these regulations. A well completion report must include the name and number of the well and a summary page or pages, located at the beginning of the report, which sets out in concise form basic information relating to the well found in the report.[1308]

In Colorado, COGCC rule 1002.d states that:

> The drilling location shall be designed and constructed to provide a safe working area while reasonably minimizing the total surface area disturbed.[1309]

[1302] COGCC rule 317B at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1303] COGCC rule 341 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1304] COGCC rule 903 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1305] COGCC rule 904 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1306] COGCC rule 906 at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1307] *Petroleum and Geothermal Energy Regulations 2013* (SA), r 38
[1308] *Petroleum and Geothermal Energy Regulations 2013* (SA), r 40
[1309] COGCC rule 1002(d) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

At the conclusion of hydraulic fracturing in Colorado operators must complete a chemical disclosure registry form and post it on the chemical disclosure registry.[1310] Any information received by the COGCC or posted to the registry (unless a trade secret) is public information.[1311] The COGCC and the public can search for information by geographic area, ingredient, chemical abstract service number, time period, and operator.[1312]

4.3.6 Conclusion

The author favour the implementation of pre and post construction wellbore reviews on wells permitted in Western Australia and South Australia. In Colorado, pre-construction reviews are carried out to verify that the wellbore will isolate fresh water from hydrocarbons. The author supports field inspections to monitor drilling and completion operations, including hydraulic fracturing. Once wells are constructed operators should provide the DMIRS and the DPC with well log data, service reports, and daily field reports to confirm that casings were installed pursuant to approved permits, rules and policies.

Operators should be required to provide daily drilling reports that include information on operations carried out during the reporting period, a description of the formations, and the depth of any geological formation tops encountered during the reporting period and also well logs acquired during the reporting period. Operators should be required to retain appropriate operational records to enable them to make and substantiate reports required by regulators and submit chemical disclosure forms within a specified time after the conclusion of hydraulic fracturing.

The author favours the implementation of Underground Injection Formation Permit Application and Injection Well Permit Application processes to manage the injection/reinjection of wastewater.

[1310] COGCC rule 205(b)(2)(A) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

[1311] COGCC rule 205(2)(D) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

[1312] COGCC rule 205A(3) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

4.4 Decommissioning and rehabilitation

> The practice of safely decommissioning a well, dismantling facilities and rehabilitating land to its natural state or some other form desired by society has been common practice in the petroleum industry for many decades and the industry has developed state-of-the-art skills in performing this function.[1313]

Western Australia considers decommissioning a petroleum activity under the PGERA Environment Regulations. By comparison, the PGEA does not consider decommissioning, abandonment and rehabilitation regulated activities.[1314] There are no specific legislative provisions in the PGERA or PGEA that require operators to carry out specific decommissioning and rehabilitation in a particular way.

The PGERA and PGEA do not treat abandonment and reclamation in the same way as the OGCA. They are not considered petroleum operations under the PGERA or regulated activities under the PGEA. They are considered oil and gas operations under the OGCA. The PGERA does refer to decommissioning and rehabilitation and the PGEA to decommissioning, abandonment and rehabilitation. The COGCC rules deal extensively with abandonment and reclamation.

In Western Australia, environmental plans contain well abandonment and decommissioning information, field closure plans and details about rehabilitation. In these documents, operators describe their plans for field closure. They are also required to submit final well activity reports which includes the status of wells, i.e., whether they are producing, suspended or decommissioned and if applicable, information on cementing operations and schematics of decommissioning. A well completion form[1315] is also required that includes the status of a

[1313] Parliamentary Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, Submission for the Chamber of Minerals and Energy Western Australia, September 2013, pg 38 at http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/99D8D0023E339C6F48257C4000110456/$file/ev.fra.131004.sub.112.the+chamber+of+minerals+and+energy+of+western+australia.pdf

[1314] *Petroleum and Geothermal Energy Act* 2000 (SA), s 10

[1315] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 74(1)

well[1316] and (if applicable) information on cementing operations and schematics of decommissioning.[1317]

In South Australia, the DPC must be advised of an operator's intentions with respect to decommissioning, abandonment and rehabilitation. Operators must provide specific details of well completion or abandonment. The term of an associated activities licence for regulated activities may take may take into account any decommissioning, rehabilitation or other action that may be required at the conclusion of the activities.

When compared to the COGCC rules, the PGERA and PGEA regulations are lacking. In Colorado, details of proposed abandonment operations must be provided to the COGCC. As is the case under the PGERA and PGEA, operators in Colorado must also provide a current wellbore diagram and a wellbore diagram showing the proposed plugging procedure.

There are no specific provisions in the PGERA or PGEA that deal with the relationship between landowners and operators with respect to decommissioning and rehabilitation. In Colorado, operators must use their best efforts to consult in good faith with surface owners, which give surface owners the chance to provide feedback on the timing of operations and on final reclamation, including the desired final land use and seed mix to be applied. An operator who wishes to abandon a well in Colorado must comply with specific regulatory requirements, contractual obligations, and lessor and landowner requirements. There are no lessor and landowner requirements in the PGERA or PGEA.

Another issue not contemplated in the PGERA or PGEA relates to the exploitation of wells by landowners. In Colorado, if a landowner wishes to exploit a well for fresh water, the well does not require filling above the required sealing plug set below the fresh water; provided the landowner has given written authority and assumes responsibility to plug the well upon its abandonment.[1318] A well may be temporarily abandoned if it is cased or left in a way that

[1316] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 9, Item 6
[1317] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 9, Item 30
[1318] COGCC rule 319(a)(7) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>

prevents migration of gas, water or other substance from its original formation or horizon.[1319] An application to temporarily abandon a well must advise why the well is being temporarily abandoned and future plans for its use.[1320]

The COGCC rules require operators to submit three very straight forward reports. These are the well abandonment report, notice of intent to abandon report and subsequent report of abandonment. The PGERA and PGEA are silent on the protection of fresh water strata in terms of decommissioning and rehabilitation. The COGCC must authorise the removal of surface casing from wells COGCC. The COGCC must approve the plugging method and be advised of the estimated time and date of plugging and identify the depth and thickness of all known sources of groundwater.[1321] Within three months of plugging a well in Colorado, operators must back fill all pits, mouse and rat holes and cellars and the remove all waste. They must abandon gathering line risers, flowline risers, and surface equipment. Operators close, grade and re-contour all access roads to plugged and abandoned wells and related production facilities.

The COGCC rules explicitly state that surface land must be restored to the condition it was at the start of the drilling operation. Disturbed areas no longer needed must be restored and revegetated as soon as practicable. The COGCC rules set out that operators should locate, construct and maintain well sites, production facilities, gathering pipelines, and access roads (unless they already have access roads) to satisfactorily control dust and minimise erosion, alteration of natural features, remove surface materials, and degradation due to contamination.[1322] Those areas affected by drilling or subsequent operations, excluding those that are needed for production purposes or for subsequent drilling operations commencing within twelve months, must be reclaimed to their previous condition or in a way that makes them suitable for their final land use as chosen by the landowner and must be maintained to control dust and minimise erosion to a level that is practicable.[1323]

[1319] COGCC rule 319(b)(1) at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1320] COGCC rule 319(b)(3) at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/Complete%20Rules%20as%20of%20May%201,%202018.pdf>
[1321] COGCC rule 319(a)(6) at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf>
[1322] COGCC rule 1001(e)(1) at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf>
[1323] COGCC rule 1003(b) at <https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf>

4.4.1 Western Australia - FMP, WMP and EP

The PGERA refers to 'decommissioning and rehabilitation'.[1324] In Western Australia, an operator must remove all property brought into that area by any person engaged or concerned in the operations, to plug or close off wells, to make provision for the conservation and protection of the natural resources and to make good damage to the Earth's crust in that area caused by any person engaged or concerned in those operations.[1325]

Decommissioning and rehabilitation in Western Australia are carried out in accordance with a FMP, WMP and EP.[1326] Wells that are considered non-productive and those that have been completely exploited must be plugged, sealed, decommissioned and sites rehabilitated.[1327] Decommissioning involves the removal of infrastructure; equipment; fuel, chemical and hazardous materials, and the treatment of residual drill cuttings piles and naturally occurring radioactive minerals.[1328] Rehabilitation involves the removal of soil and cuttings stockpiles, sumps and fluid ponds, soil re-contouring and stabilisation, re-vegetation of cleared areas, weed control and removal and disposal of waste (food scraps, concrete, plastic packaging, septic waste, tyres, scrap metals, liquid wastes and hazardous wastes).[1329]

Western Australian operators must manage well abandonment and include specific details in the EPs they submit to the DMIRS[1330] and must monitor the rehabilitation activities carried out on a production site for an appropriate period of time after decommissioning before their licence can be surrendered.[1331] An EP must summarise the rehabilitation activities that an

[1324] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA) and *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA)
[1325] Section 101 of the PGERA
[1326] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) Part 2
[1327] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in WA, A Whole of Government Approach, 2015 Edition, pg 21 at <https://www.DMIRS.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf>
[1328] Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, Department of Mines and Petroleum 2013, p 17 at <http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf>
[1329] Id at 16.
[1330] *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) Part 2
[1331] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in WA, A Whole of Government Approach, 2015 Edition, pg 21 at <http://www.DMIRS.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf>

operator intends to carry out and their objectives and commitment for the areas impacted by proposed activities.[1332]

EPs must address decommissioning and rehabilitation and include a safety management system/safety case.[1333] For example, the Canning Basin EP[1334] states that where there are no signs of gas, a well will be plugged and abandoned by putting cement plugs in the open hole and at the surface.[1335] The rehabilitation of access tracks, well sites and camps must commence within three months of plugging and abandonment.[1336] The Canning Basin JV EP[1337] states that at the completion of drilling, a well will be suspended or plugged and abandoned.[1338] Well sites will also be demobilised in accordance with the EP.[1339] Within a year of plugging and abandoning a well, rehabilitation must commence in accordance with rehabilitation standards.[1340] The DMIRS carries out inspections to determine compliance against approved EPs.[1341] If decommissioning is not adequately explained in the EP that has been approved by the DMIRS, the operator must include a commitment that a decommissioning EP will be submitted prior to the decommissioning activities commencing.[1342]

[1332] Submission to the Legislative Council Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, Department of Mines and Petroleum 2013, p 16 at <http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/C4EBD44EB7D29B4848257C40000F2471/$file/ev.fra.131003.sub.105.department+of+mines+and+petroleum.pdf>

[1333] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in WA, A Whole of Government Approach, 2015 Edition, pg 31 at < http://www.dmp.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf>

[1334] Buru Energy, Canning Basin Well Drilling Environment Plan Summary Document, 2013, pg 11 at <http://www.buruenergy.com/wp-content/uploads/Canning-Basin-Well-Drilling-Environment-Plan.pdf>

[1335] Ibid.

[1336] Ibid.

[1337] Buru Energy, Jackaroo 1 and Victory 1 Well Drilling Environment Plan Bridging Document: Summary Document, 2015 at http://www.buruenergy.com/wp-content/uploads/HSE-SUM-021_Jackaroo-1-and-Victory-1-Well-BD-Summary-Doc.pdf

[1338] Id at 4.

[1339] Ibid.

[1340] Ibid.

[1341] Department of Mines and Petroleum, Guide to the Regulatory Framework for Shale and Tight Gas in WA, A Whole of Government Approach, 2015 Edition, pg 21 at <http://www.DMIRS.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf>

[1342] Department of Mines and Petroleum, Guideline for the Development of Petroleum and Geothermal Environment Plans in Western Australia, November 2016, pg 14

WMPs[1343] must contain well abandonment and decommissioning information, field closure plans and details about rehabilitation.[1344] A WMP that fails to detail the risks associated with abandonment will be rejected by the DMIRS (WA) (delaying the commencement of activities) and reassessed if additional information is requested.[1345] An activity program that describes the process; that contains pre- and post-decommissioning diagrams; justifies if a well is no longer economically viable and provides information in relation to wellhead removal and regeneration of the site must also be lodged.[1346] An operator wishing to decommission a well must insulate the production zone with a cement plug[1347] and place barriers in the well casing to prevent fluids from entering or exiting the well once the wellhead is disconnected.[1348] A WMP must identify the risks to well integrity and set out in some detail how an operator intends to manage risk in accordance with sound engineering principles, codes, standards and specifications.[1349]

A FMP must provide an account of the life cycle of a project covered by a production licence and typically include decommissioning and rehabilitation processes following completion of resource extraction.[1350] It must include a description of an operators plan for field closure[1351] and describe the lifecycle of a project covered by an operator's production licence and how the project will be managed.[1352] A FMP must list the aquifers that may be affected by exploration and production, baseline monitoring of groundwater sources, information about proposed

[1343] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Part 3
[1344] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 1 and 3
[1345] Department of Mines and Petroleum, Guidelines for the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015, , p 23 at <http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-SBD-ADM-180D.pdf>
[1346] Department of Mines, Industry Regulation and Safety, Western Australia's Petroleum and Geothermal Explorer's Guide, 2014 Edition, pg 109 at < http://www.dmp.wa.gov.au/Documents/Petroleum/PD-RES-PUB-100D.pdf>
[1347] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in WA, A Whole of Government Approach, 2015 Edition, pg 31 at <http://www.dmp.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf>
[1348] Id at 21.
[1349] Id at 31.
[1350] Id at 40.
[1351] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 3, Item 16
[1352] Department of Mines, Industry Regulation and Safety, Guide to the Regulatory Framework for Shale and Tight Gas in WA, A Whole of Government Approach, 2015 Edition, pg 31 at http://www.dmp.wa.gov.au/Documents/Petroleum/WEB_Shale_and_Tight_Gas_Framework.pdf>

injection of the resource or of water into underground formations and descriptions of an operator's plans for closure of the field and decommissioning and rehabilitation.[1353]

Operators must submit final well activity reports[1354] which include the status of wells, that is, whether they are producing, suspended or decommissioned[1355] and if applicable, information on cementing operations and schematics of decommissioning.[1356] A well completion form[1357] is also required, which includes the status of a well[1358] and (if applicable) information on cementing operations and schematics of decommissioning.[1359] If a field is being decommissioned, an operator must lodge a field decommissioning plan as part of the FMP specifying the decommissioning procedure and a description of the decommissioning of the wells, including removal of the wellheads.[1360]

4.4.2 South Australia – SEO

The PGEA refers to 'decommissioning, abandonment and rehabilitation'.[1361] Decommissioning, abandonment and rehabilitation in South Australia are carried out in accordance with SEOs.[1362] An operator who undertakes drilling must provide specific details of well completion or abandonment.[1363] Operators must not plug, backfill or seal a well unless authorised to do so by a water management authorisation or permit.[1364] The NRMA stipulates

[1353] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 43
[1354] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 73(1)
[1355] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 7, Item 5
[1356] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 7, Item 22
[1357] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), r 74(1)
[1358] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 9, Item 6
[1359] *Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015* (WA), Schedule 9, Item 30
[1360] Department of Mines and Petroleum, Western Australia's Petroleum and Geothermal Explorer's Guide, 2014 Edition, pg 109 at <http://www.DMIRS.wa.gov.au/Documents/Petroleum/PD-RES-PUB-100D.pdf>
[1361] *Petroleum and Geothermal Energy Act 2000* (SA) and *Petroleum and Geothermal Energy Regulations 2013* (SA)
[1362] *Petroleum and Geothermal Energy Regulations 2013* (SA), r 13(1)(e)
[1363] *Petroleum and Geothermal Energy Regulations 2013* (SA), r 40(2)(n)
[1364] *Natural Resources Management Act 2004* **(**SA), s 127

that it is a condition of a permit to plug, backfill or seal a well or to repair, replace or alter the casing, lining or screen of a well that the work be undertaken by licensed well driller or is supervised by a licensed well driller.[1365] The term of an associated activities licence for regulated activities may take may take into account any decommissioning, rehabilitation or other action that may be required at the conclusion of the activities.[1366]

An SEO is prepared on the basis of an Environmental Impact Report (EIR).[1367] An SEO and EIR must address potential impacts on aquifers, including contamination; impacts on groundwater use; surface water use, shallow groundwater and water storage ponds.[1368] Santos' Cooper Basin SEO[1369] deals with well and zonal decommissioning[1370] and rehabilitation.[1371] Rehabilitation is carried out in accordance with environmental objective six which relates to minimising loss of aquifer pressure and the avoidance of aquifer contamination.[1372] To achieve objective six the SEO states that solation barriers must be in place to ensure that crossflow, contamination or pressure reduction does not occur; barriers must meet or exceed the requirements of applicable standards for the decommissioning of petroleum wells; and isolation barriers should be placed to isolate the groups of formations. The number may be varied from the standard approach on a case-by-case basis and in consultation and or with approval from DPC.1373

Santos' Cooper Basin EIR1374 sets out the events that are reasonably foreseeable and that could pose a threat to the environment (including events during decommissioning).[1375] Where a well or zone needs to be decommissioned, specific aspects of the well must be considered

[1365] *Natural Resources Management Act 2004* (SA), s 135(11)
[1366] *Petroleum and Geothermal Energy Act 2000* (SA), s 58(2)
[1367] Id section 97.
[1368] Department of Statement Development, Statement of Environmental Objectives, (accessed 18 June 2017) <http://petroleum.statedevelopment.sa.gov.au/legislation/regulation/seo>
[1369] Santos, SA Cooper Basin, Statement of Environmental Objectives: Drilling, Completions and Well Operations, November 2015 at <https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGER00246SEO%20DRILLING%20OPERATIONS.pdf>
[1370] Id at 4.
[1371] Id at 7.
[1372] Ibid.
[1373] Id at 13.
[1374] Santos, SA Cooper Basin, Environmental Impact Report: Drilling, Completions and Well Operations, November 2015 at <https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGER00245EIR%20DRILLING%20OPERATIONS.pdf>
[1375] Id at 6.

when developing an appropriate decommissioning procedure.[1376] The EIR classifies wells as; cased and suspended (C&S), producing, decommissioned and suspended/inactive.[1377] Decommissioning of the well bore and surface infrastructure commences once production infrastructure and facilities have been removed.[1378]

When drilling is complete, well testing is carried out to determine production potential and a judgement is made about whether to run a cement production casing or plug and decommission the well.[1379] If a well is plugged, the drilling string[1380] is removed from the hole and the production casing is run into the well bore and cemented in place.[1381] When an operator plugs and decommissions a well, consideration is given to isolating all formations that contain gas; isolating Permian formations from Jurassic aquifers; setting plugs across intermediate casing shoe (if present) to minimise the potential for cross flow between aquifers and gas bearing intervals as defined in the SEO; setting plugs across surface casing shoe; and at the surface set a plug in the well prior to cutting off the surface casing bowl.[1382]

Where issues are discovered regarding casing or cement, hydraulic fracturing is suspended until the well is remediated.[1383] If it is determined that remediation of the well is physically or economically non-viable, the well is completed without hydraulic fracturing, or plugged and decommissioned in accordance with best practices and regulatory requirements.[1384] The object of well decommissioning is to separate gas and water bearing formations.[1385]

[1376] Ibid.
[1377] Id at 9.
[1378] Id at 15.
[1379] Id at 19.
[1380] Schlumberger, Oilfield Glossary, 'Drill String', (accessed 20 May 2017) at http://www.glossary.oilfield.slb.com/Terms/d/drill_string.aspx
[1381] Santos, SA Cooper Basin, Environmental Impact Report: Drilling, Completions and Well Operations, pg 53, November 2015 at <https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGER00245EIR%20DRILLING%20OPERATIONS.pdf>
[1382] Id at 19.
[1383] Id at 53.
[1384] Ibid.
[1385] Ibid.

4.4.3 Colorado – Reclamation regulations

The OGCA refers 'abandonment and reclamation'.[1386] Plugging and abandonment denotes 'the cementing of a well, the removal of its associated production facilities, the removal or abandonment in-place of its flowline, and the remediation and reclamation of the well site.'[1387] Operators must submit a well abandonment report form to the COGCC,[1388] a 'Notice of Intent to Abandon' and 'Subsequent Report of Abandonment'.[1389]

The COGCC rules 'establish the proper reclamation of the land and soil affected by oil and gas operations and ensure the protection of the topsoil of said land during such operations.'[1390] The surface of the land shall be restored as nearly as practicable to its condition at the commencement of drilling operations.[1391]

In order to reduce land disturbance and to facilitate future reclamation 'well sites, production facilities, gathering pipelines, and access roads shall be located, adequately sized, constructed, and maintained so as to reasonably control dust and minimize erosion, alteration of natural features, removal of surface materials, and degradation due to contamination.'[1392]

The COGCC rules set out that roads must be used to avoid erosion and minimise the land area devoted to gas operations and roadbeds must be engineered to avoid or minimise impacts to riverbanks or wetlands to the extent possible.[1393]

[1386] COGCC series 300 rules (drilling, development, production and abandonment) and its 1000 rules (Reclamation Regulations)
[1387] COGCC rules, definitions
[1388] COGCC Form 6, Well Abandonment Report at <http://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/form6.pdfhttp://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/form6.pdf>
[1389] COGCC Form 6, Well Abandonment Report at <http://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/form6.pdf>
[1390] COGCC rule 1001 (Reclamation Regulations) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1391] COGCC rule 1001 (Reclamation Regulations) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1392] COGCC rule 1002.e.(1) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1393] COGCC rule 1002.e.(4) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf

In Colorado, an operator must provide details of proposed abandonment operations to the COGCC.[1394] They must outline the anticipated depths of mechanical plugs and casing cuts, the anticipated depths and volumes of all cement plugs, the amount, size and depth of casing and junk to be left in the well, the volume, weight, and type of fluid to be left in the wellbore between cement or mechanical plugs and the nature and quantities of any other materials to be used in the plugging.[1395] Operators must provide a current wellbore diagram and a wellbore diagram showing the proposed plugging procedure.[1396]

When preparing for final reclamation, plugging and abandonment operators must use their best efforts to consult in good faith with surface owners (or tenants).[1397] Operators must aim to give surface owners (or there appointed agent) the chance to provide feedback in relation to the timing of operations and on final reclamation, including the desired final land use and seed mix to be applied.[1398] An operator who wishes to abandon a well must comply with specific regulatory requirements, contractual obligations, and lessor and landowner requirements.[1399]

Following abandonment, operators must provide an account of the manner in which it was performed, casing pressure test results and downhole logs runs.[1400] Operators must provide plugging verification reports which specify the depths of mechanical plugs and casing cuts, the depths and volumes of all cement plugs, the amount, size and depth of casing and 'junk' left in the well, the volume and weight of fluid left in the wellbore and the nature and quantities of any other materials used in the plugging.[1401] An operator must notify the COGCC prior to re-entering a plugged and abandoned well for the purpose of re-plugging the well.[1402]

To protect fresh water strata, no surface casing is to be removed from a well unless an operator receives authorisation from the COGCC.[1403] An operator must obtain prior approval of the

[1394] COGCC rule 311(a) and COGCC Form 6, Well Abandonment Report at <https://cogcc.state.co.us/documents/reg/Forms/PDF_Forms/form6.pdf>
[1395] COGCC rule 311(a) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1396] COGCC rule 311(a) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1397] COGCC rule 306.e.f at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1398] COGCC rule 306.e.f at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1399] API, Environmental Protection for Onshore Oil and Gas Production Operations and Leases, API Recommended Practice 51R, First Edition, July 2009, pg 11 at <http://www.api.org/~/media/Files/Policy/Exploration/API_RP_51R.pdf>
[1400] COGCC rule 311(b) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1401] COGCC rule 311(b) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1402] COGCC rule 311(c) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1403] COGCC rule 319(a)(4) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf

plugging method and advise the COGCC of the estimated time and date of plugging and identify the depth and thickness of all known sources of groundwater.[1404] All access roads to plugged and abandoned wells and related production facilities must be closed, graded and re-contoured. [1405]

In Colorado, surface land must be restored to the condition it was in at the start of the drilling operation[1406] i.e., disturbed areas no longer needed must be restored and revegetated as soon as practicable.[1407] The COGCC rules set out that operators should locate, construct and maintain well sites, production facilities, gathering pipelines, and access roads to satisfactorily control dust and minimise erosion, alteration of natural features, removal of surface materials, and degradation due to contamination.[1408] Those areas affected by drilling or subsequent operations, excluding ones that are needed for production purposes or for subsequent drilling operations commencing within twelve months, must be reclaimed to their previous condition or in a way that makes them suitable for their final land use as chosen by the landowner and must be maintained to control dust and minimize erosion to a level that is practicable.[1409]

The plugging, sealing and abandonment of wells is required to avoid contamination of ground water and the migration of water through a well's borehole.[1410] A well owner is responsible for having an existing well properly plugged, sealed and abandoned.[1411] Moreover, a well construction contractor or authorised person is responsible for informing the well owner in writing of these plugging requirements.[1412]

[1404] COGCC rule 319(a)(6) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/300Series.pdf
[1405] COGCC rule 1004(a) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1406] COGCC rule 1001(a) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1407] COGCC rule 1003(e) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1408] COGCC rule 1001(e)(1) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1409] COGCC rule 1003(b) at https://cogcc.state.co.us/documents/reg/Rules/LATEST/1000Series.pdf
[1410] Rule 16 of the Water Well Construction Rules at http://water.state.co.us/DWRIPub/Documents/gws-09.pdf
[1411] Rule 16 of the Water Well Construction Rules at http://water.state.co.us/DWRIPub/Documents/gws-09.pdf
[1412] Rule 16 of the Water Well Construction Rules at http://water.state.co.us/DWRIPub/Documents/gws-09.pdf

4.4.4 Conclusion

The author contends that the PGERA and PGERA should require operators to carry out decommissioning and rehabilitation in a similar vein to the COGCC rules. Western Australia and South Australia do not treat abandonment and reclamation in the same way as Colorado. These activities are not considered petroleum operations under the PGERA or regulated activities under the PGEA. By comparison they are deemed oil and gas operations under the OGCA. It is concerning that the PGERA does specifically refer to decommissioning and rehabilitation and the PGEA to decommissioning, abandonment and rehabilitation. The COGCC rules deal extensively with abandonment and reclamation.

The author favours Colorado's approach where specific details of proposed abandonment operations must be provided to the COGCC. The PGERA and PGEA should include specific provisions that deal with the relationship between landowners and operators with respect to decommissioning and rehabilitation as is the case in Colorado where operators must use their best efforts to consult in good faith with surface owner which gives surface owners the chance to provide feedback on the timing of operations and on final reclamation, including the desired final land use and seed mix to be applied. An operator abandoning a well in Colorado must comply with specific regulatory requirements, contractual obligations, and lessor and landowner requirements. There are no lessor and landowner requirements in the PGERA or PGEA.

The author favour Colorado's approach where operators submit three straight forward reports that deal with well abandonment, a well abandonment report, abandonment intention report and a report after abandonment has occurred. The PGERA and PGEA are silent on the protection of fresh water strata in terms of decommissioning and rehabilitation. The COGCC must authorise the removal of surface casing from wells COGCC. The COGCC rules explicitly state that surface land must be restored to the condition it was at the start of the drilling operation them suitable for their final land use as chosen by the landowner and must be maintained to control dust and minimise erosion to a level that is practicable.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The production of shale and tight gas globally has been characterised by:

> … a tendency for all stakeholders to assume that old oil and gas regulations are good enough, because they have worked in the past. But, as we have seen, shale gas development, particularly its rapid pace and large scale, brings with it new risks, and new variations of old risks. These new and different risks do not necessarily mean that development should stop. But, it is critical that all stakeholders commit to continued discussion of risks, and policies that might address them.[1413]

Australia has the potential to follow the U.S and become one of the largest producers of shale and tight gas in the world, given that it reportedly holds 437 trillion cubic feet (tcf) of technically recoverable shale gas. The Canning Basin, located in Western Australia is reported to contain 235 tcf or roughly double the amount of gas held in the state's offshore conventional fields. By comparison the U.S. reportedly holds 610 tcf of technically recoverable shale gas.

The significant increase in shale and tight gas production in the United States over the last decade has fuelled debate about the effectiveness of regulatory regimes to deal with access to land, drilling, water exploitation and post tenure liability. The thesis has undertaken a comparative analysis of how Western Australia, South Australia and Colorado have addressed each of these regulatory issues. That analysis leads to the following recommendations for reform for Australian jurisdictions' regulatory frameworks.

[1413] Rahm, B, G and Riha, S, J, Evolving shale gas management: water resource risks, impacts, and lessons learned, Environ. Sci: Processes Impacts, 2014, 16, 1400, page 1409 at http://pubs.rsc.org/en/content/articlepdf/2014/EM/C4EM00018H

5.2 Recommendations

Recommendation 1

The author recommends that Western Australia and South Australia consider inserting a reasonable accommodation provision (similar to the OGCA) into the PGERA and PGEA.

This provision would be an entirely new feature and require operators to carry out shale and tight gas exploration, production and abandonment activities in a way that supports surface owners and reduces disturbance upon and damage to surface lands.

Recommendation 2

Western Australia and South Australia should develop statutory frameworks for land access agreements. In the absence of this, their respective land access agreement templates should be amended to:

a) protect landowners from having their entire property held under a lease when shale and tight gas production is taking place on a very small section;
b) specify the location of wells given that drilling pads can be located some distance away from gas deposits;
c) outline the frequency of an operator's entry to a landowner's property and, after a well is drilled, consideration should be given to the frequency of monitoring;
d) deal with surface disturbance, interim reclamation, pits, waste disposal, groundwater impacts, noise impacts, dust impacts visual impacts, water rights, fencing, damage, timing of operations and current land use;
e) specify whether operators intend to co-locate wells on single well pads to minimise surface impacts; and
f) set out a negotiation process that deals with the location of roads and vehicle access; in particular, whether there is an intention to construct temporary roads and a process for the negotiating transport plans.

Recommendation 3:

The author recommends that the DMIRS adopt the DPC's approach to environmental management given the PGEA has a much more robust environmental management regime than the PGERA. Consideration should be given to amending the PGERA environmental plan to mirror the PGEA's SEO.

SEOs go far beyond what is needed in an EP under the PGERA. For example, SEOs explicitly address impacts on aquifers, impacts on groundwater use, contamination of surface water and shallow groundwater, water storage ponds, flow-back storage ponds and rehabilitation. EPs do not do this to the same extent.

Recommendation 4:

The author recommends that the PGERA and PGEA should be amended to include provisions that set internal, intermediate, and external buffer areas to protect surface waters in and around the Canning Basin and Cooper Basins. The author suggests that this would safeguard surface public water sources through additional protections when gas facilities are situated close to designated surface water sources. It would also prevent gas facilities from being located within a certain distance from designated water sources.

Recommendation 5:

The author recommends the insertion of a provision in PGERA and PGEA to allow operators to lodge voluntary comprehensive drilling plans. These plans would ensure that anticipated gas activities are identified and that there is a discussion about potential impacts and the identification of measures to reduce adverse impacts to the environment. The DMIRS and DPC should encourage operators to liaise with their respective EPAs and surface owners to compile these plans.

Recommendation 6:

The author recommends that the PGERA and PGEA should be amended to include provisions for a baseline and post-completion groundwater monitoring regimes similar to that which exists in the COGCC rules. The DMIRS and DPC should follow the COGCC's lead and implement rules dealing with cement bond logs, mechanical integrity tests and bradenhead tests. These are all critically important for safeguarding a well's integrity.

Recommendation 7:

The author supports, as a bare minimum, the introduction of baseline water sampling in the Canning Basin and Cooper Basin. This is consistent with the approach taken in Colorado's Greater Wattenberg Area. It is makes regulatory sense to ensure monitoring is carried out where most gas production occurs.

Recommendation 8:

The author recommends that Western Australia and South Australia implement restrictive stormwater rules applicable to shale and tight gas activities. Both jurisdictions should develop their own best management practices and database for shale and tight gas development.

Recommendation 9:

The author favours well setback rules that exist in Colorado. These rules ensure precautions are taken near surface waters used for drinking. It also favours its pit permitting and reporting requirements and pit lining requirements. The COGCC rules require that spills and releases are reported to the COGCC, CDPHE and the landowner.

Recommendation 10:

The author recommends that the DMIRS and DPC actively encourage and promote the reduction of waste by allowing operators to submit management plans that deal with

beneficial use, reuse and recycling. The author favours the COGCC underground injection authorisation regime.

Recommendation 11:

The author favours Colorado's chemical disclosure system where operators complete a chemical disclosure registry form and upload it onto FracFocus. Any information that is posted to the site or sent to the COGCC (unless a trade secret) is public information. The COGCC and the public can search for information by geographic area, ingredient, chemical abstract service number, time period, and operator.

Recommendation 12:

The author favours Colorado's chemical disclosure system where operators submit chemical disclosure forms within 60 days of the conclusion of hydraulic fracturing. The author also favours the approach whereby operators who claim that the identity or concentration of a chemical is a trade secret do not need to disclose them on their disclosure form, though the information must be provided to the COGCC if it is requested.

Recommendation 13:

The author recommends the DMIRS and DPC include in the PGERA and PGEA preliminary baseline sampling and subsequent monitoring requirements where all available water sources within 800 metres of a proposed gas well, multi-well site, or dedicated injection well. The author recommends subsequent sampling is carried out at the initial sample locations and subsequent sampling is conducted following completion of the well or dedicated injection well or the last well on a multi-well site.

Recommendation 14:

The absence in the PGERA and PGEA of a legal statement regarding decommissioning and reclamation is not ideal. The PGERA should be amended to include decommissioning and the

PGEA to decommissioning, abandonment and rehabilitation. The COGCC rules deal extensively with abandonment and reclamation.

Recommendation 15:

The author favours Colorado's best efforts approach. There are no specific provisions in the PGERA or PGEA that deal with the relationship between landowner and operators with respect to decommissioning and rehabilitation. By comparison, the COGCC rules require operators to use their best efforts to consult in good faith with surface owner, which gives surface owners the chance to provide feedback on final reclamation.

Recommendation 16:

The author favours Colorado's command and control approach to regulation, at least in the early stages of Western Australia's and South Australia's journey to exploiting shale and tight gas. This approach will likely alleviate the some of the concerns of held by those vehemently opposed it.

5.3 Summary of Key Issues

This section summarises the gaps that this thesis contends exist in Western Australia and South Australia in relation to the exploitation of shale and tight gas and land access, water access and quality protection, regulation of well technology for drilling and hydraulic fracturing and decommissioning and associated issues.

Regulating the exploitation of shale and tight gas is a difficult task for governments and by implication for the regulatory bodies that are tasked with turning these policies into regulatory regimes. Ultimately, regulatory regimes will be judged by communities and they will either be supported or rejected. Wide spread discontent can result in bans and moratoria.

This current angst with exploiting shale and tight gas in Western Australia and, to a lesser extent, South Australia is largely due to concerns about land access and the complex exploration and production techniques required to facilitate extraction, the evolving

understanding of risks and challenges by some jurisdictions and the rapid pace of development. The arid conditions in the Canning Basin and Cooper Basin could result in considerable exploration, production and abandonment challenges. A particular issue will be water resource management.

Large amounts of water are needed to exploit shale and tight gas through the use of horizontal drilling and hydraulic fracturing. The use of both of these techniques in the United States has resulted in an average annual growth rate of nearly 50 per cent in shale gas production.[1414] Western Australia and South Australia will need to deal with water sustainability; contamination and competition issues that will overshadow other environmental issues in their pursuit of shale and tight gas.

The water required for shale and tight gas production in Western Australia and South Australia will be surface water (streams, ponds or lakes); groundwater (aquifers) or water from alternative sources (drainage water, from recycling or transported by truck or rail). A developed industry located in or around the Canning Basin (WA) or Cooper Basin (SA) – both arid areas - will be a significant exploiter of groundwater relative to sustainable extraction levels.

Shale and tight gas reserves located in arid regions and producers may be have to rely solely on groundwater to undertake hydraulic fracturing, in fact groundwater will likely be the only water available in some areas. Where groundwater recharge rates are low there will be challenges for both operators and regulators.

The negative impacts on water resources could, if not appropriately managed, cause environmental and production issues beyond immediate production areas. The author rejects the notion that the rapidity of change in the shale and tight gas industry has often outpaced the availability of information for regulators to develop specific guidance. This defence for simply overlooking regulatory gaps should not be used.

[1414] Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, Crawford School of Public Policy, 2012, pg 6 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF

This thesis favours a number of the approaches taken to shale and tight gas development in Colorado over the approaches currently taken in Western Australia and South Australia. With respect, the PGERA and PGEA lack a number of pre-emptive sections to deal with issues that will likely face shale and tight gas operators in Western Australia and South Australia respectively. Western Australia and South Australia have been largely reactive in regulating and though they are in the early stages of exploration and full scale production, this is not a satisfactory justification.

Colorado has an embedded regulatory framework and is in the advanced stage of shale gas development, with all their elements operating as a system. With respect, Western Australia (and to a lesser extent South Australia) is playing a game of 'follow the leader' and 'regulatory catch-up'. Neither has kept pace with the significant risks and challenges linked to shale and tight gas development. The OGCA and COGCC rules should be used to amend the PGERA and PGEA.

This thesis favours South Australia's regulatory approval process over that of Western Australia. A PGEA exploration licence application must include a prospectivity assessment and an outline how the proposed work program relates to it this assessment. There is no requirement under the PGERA for operators to assess prospectivity when they apply for an exploration permit.

This thesis favours Colorado's permit to drill application, given that it specifies the distance between the well and wall or corner of the nearest building, public road, above ground utility, railroad, and property line. This is vastly different to the PGERA and PGEA, where there no requirement to consider anything other than the resources being targeted for exploration and production.

This thesis favours the PGEA's consultation requirements over those in the PGERA. In South Australia, stakeholders, including landholders, must be informed and advised on the potential risks associated with proposed activities, and the management strategies that will be used to minimise risk. They must also be provided with the opportunity to raise any issues of concern before regulated activities commence. The DPC expects that licensees will consult stakeholders prior to and during the development of their EIR and SEO, to describe their activities and the potential impacts which may be experienced.

The PGEA also has a much more robust environmental management regime than the PGERA. Although the PGERA requires an operator to describe the regulated activities they intend to undertake and provide information about environmental impacts and risks from exploitation to the existing environment, and requires a risk assessment process be used to evaluate those impacts and risks, this information is only provided prior to the regulated activities being carried out and does not include any detail after they have been completed. In setting out how land adversely affected by regulated activities will be rehabilitated, an SEO goes far beyond what is needed in an EP. SEOs explicitly address impacts on aquifers, impacts on groundwater use, contamination of surface water and shallow groundwater, water storage ponds, flow-back storage ponds. EPs do not do so to the same extent.

If Western Australia's current ban and moratoria on exploiting shale and tight gas is lifted, the author recommends that the DMIRS adopt a command and control approach in the short term. Command and control is ideal for the early stages of regulatory intervention. This may alleviate some of the concerns held by those vehemently opposed to it. This approach will allow the DIMRS to set clear limits and to administer them within a legislative framework. The author does not believe that using a command and control approach will result in community disengagement or operator distrust. Implementing a command and control approach may provide a satisfactory basis for the industry to gain a social licence to operate.

Bibliography

Accenture. (2015). *Water and Shale Gas Development.* London: Accenture.

Ackerman, F., & Heinzerling, L.,Priceless: On Knowing the Price or Everything and the Value of Nothing, The New York Press, 2004)

Adair, S. K., Pearson, B. R., Monast, J., Vengosh, A., & Jackson, R. B. (2012). Considering Shale Gas Extraction in North Carolina: Lessons from other states. *Duke Environmental Law & Policy Forum*, 257-301.

Alberta Energy Regulator. (2015). *What is Unconventional Oil and Gas?* Retrieved July 20, 2015, from https://www.aer.ca/about-aer/spotlight-on/unconventional-regulatory-framework/what-is-unconventional-oil-and-gas

Allnutt, L. (2015, September). *Legislation, Logistics, Standards, Water Management.* Retrieved October 7, 2015, from Unconventional Oil and Gas: http://www.unconventionaloilandgas.com.au/rules-and-regulation-navigating-the-governance-maze/

Allnutt, L. (2015, June). *Norton Rose Fulbright.* Retrieved April 18, 2017, from http://www.nortonrosefullbright.com/knowledge/publications/129582/australia

American Petroluem Institute. (2010). *Water Management Associated with Hydraulic Fracturing.* Washington, DC: API Publishing Services.

American Petroleum Institute (2009), Environmental Protection for Onshore Oil and Gas Production Operations and Leases, API Recommended Practice 51R, First Edition, from <http://www.api.org/~/media/Files/Policy/Exploration/API_RP_51R.pdf>

AMMA, Resource Industry Employer Group. (2015). *Natural Gas*. Retrieved July 15, 2015, from http://www.miningoilgasjobs.com.au/oil-gas-energy/hydrocarbons-and-energy/hydrocarbons/oil-and-gas/downstream/natural-gas.aspx

APPEA. (2013). *APPEA Submission: Environment and Public Affairs Committee 'Inquiry into the Implications for Western Australia of Hydraulic Fractruring for Unconventional Gas.* Perth: APPEA.

APPEA. (2015). *APPEA Horizontal drilling*. Retrieved January 10, 2015, from http://www.appea.com.au/oil-gas-explained/operation/horizontal-drilling/

APPEA. (2015). *Experts agree best practice gas production is environmentally responsible*. Retrieved January 15, 2016, from http://www.appea.com.au/media_release/experts-agree-gas-production-can-be-environmentally-responsible-with-best-practice/

APPEA. (2015). *What is natural gas?* Retrieved June 19, 2015, from http://www.appea.com.au/oil-gas-explained/oil-and-gas/what-is-natural-gas/

APPEA. (2016). *Hydraulic Fracturing, Shale gas in Australia*. Retrieved January 15, 2016, from http://www.shale-gas.com.au/industry-operations/hydraulic-fracturing/

APPEA. (n.d.). *Western Australian Onshore Gas Code of Practice for Hydraulic Fracturing.* Perth: APPEA.

Arthur, J. D., Alleman, D., & Langhus, B. (2008). *An Overview of Modern Shale Gas Development in the United States.* ALL Consulting.

Australian Academy of Technological Sciences and Engineering (ATSE). (2013). *Response to Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas.* Canberra: ATSE.

Baldwin, R., Cave, M., and Lodge, M., Understanding Regulation, Theory, Strategy, and Practice (Oxford, 2nd Edition, 2012)

Barnett, C. J. (2013, May 8). Second Reading Speech - Natural Gas (Canning Basin Joint Venture) Agreement 2013. Perth, Western Australia: Parliament of Western Australia.

Beach Energy, Statement of Environmental Objectives, Cooper Basin Petroleum Production Operations, (accessed 12 May 2017) pg 15, http://www.beachenergy.com.au/irm/company/showpage.aspx?CategoryId=190&CPID=6631&InstanceVersionNumber=0

Benson, M. H. (2009). Intergrative Adaptive Management and Oil and Gas Development: Existing Obstacles and Opportunties for Reform. *Environmental Law Reporter*, 10962-10978.

Black, J., The Role of Risk in Regulatory Processes, in R. Baldwin, M. Cave and M. Lodge (eds), The Oxford Handbook of Regulation (Oxford 2010)

Boersma, T., & Johnson, C. (2012). *Risks and Potentials of Shale Gas Revolution, Consequences for Markets and the Environment.* German Institute for International and Security Studies .

Boschee, P. (2014). Produced and Flowback Water Recycling and Reuse, Economics, Limitations and Technology. *Oil and Gas Facilities*, 17-22.

Boutilier, R.G., & Thomson, I., Modelling and Measuring the Social Licence to Operate: Fruits of a Dialogue Between Theory and Practice (2011) International Mine Management

Brady, W. J. (n.d.). *Hydraulic Fracturing Regulation in the United States: The Laissez-Faire Approach of the Federal Government and Varying State Regulations.* Denver: Grimshaw & Harring.

Brooksby, D., Rivoli Bay Sailing Club, submission, Inquiry into Unconventional Gas and Fracking in SE of SA, 12 January 2015

Bubna-Litic, K. (2015). Fracking in Australia: The future in South Australia? *Environmental Planning Law Journal*, 437-454

Burns, R., A Fracking Debate: Greens and divided on whether to regulate fracking or hold out for a ban, In these Times, 10 July 2013

Bureau of Land Management, Split Estate, (accessed 18 May 2017) at <http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/split_estate.html>

Buru Energy. (2014). *Buru Energy's proposed gas developments in the Canning Basin - Questions and Answers.* Perth: Buru Energy.

Buru Energy, Jackaroo 1 and Victory 1 Well Drilling Environment Plan Bridging Document: Summary Document, 2015 at <http://www.buruenergy.com/wp-content/uploads/HSE-SUM-021_Jackaroo-1-and-Victory-1-Well-BD-Summary-Doc.pdf>

Burwen, J., & Flegel, J. (2013). *Unconventional Gas Exploration & Production.* Washington DC: American Energy Innovation Council.

Canadian Society for Unconventional Resources. (n.d.). *Understanding Water and Unconventional Resources.* Calgary: Canadian Society for Unconventional Resources (CSUR).

Cappellati, M. (1994). Comparative Law Teaching and Scholarship: Method and Objectives. *Asia Pacific Law Review*, 1-7.

Carr-Wilson, S. (2014). *Improving the Regulation of Fracking Wastewater Disposal in BC.* Victoria: Environmental Law Centre, University of Victoria.

Chamber of Minerals and Energy. (2013, September). Submission for Chamber of Minerals and Energy, Western Australia, Parliamentary Inquiry into the Implications for Western Austalia of Hydraulic Fracturing for Unconventional Gas. Perth, Western Australia.

Chandler, J. (2015). How are onshore licencing regimes in Australia dealing with the challenges of Petroleum in shale and other tight rocks. *The Australian Resources and Energy Law Journal*, 251-266.

Colorado Oil & Gas Conservation Commission. (n.d.). *Information for Surface Owners.* Retrieved February 2, 2016, from Colorado Oil & Gas Conservation Commission: https://cogcc.state.co.us/documents/about/Help/Surface%20Owners%20Brochure.pdf

Colorado Division of Water Resources, Department of Natural Resources, Prior Appropriation Law at http://water.state.co.us/surfacewater/swrights/pages/priorapprop.aspx

Commomwealth Scientific and Industrial Research Organisation (CSIRO). (2015). *What is unconventional gas?* Retrieved July 20, 2015, from http://www.csiro.au/en/Research/Energy/Hydraulic-fracturing/What-is-unconventional-gas

Commonwealth Scientific and Industrial Research Organisation. (2015). *What is hydraulic fracturing? A comprehensive explanation of the method used by the oil and gas industry to increase the rate and total amount of gas and oil extracted from reservoirs*. Retrieved October 11, 2015, from http://www.csiro.au/en/Research/Energy/Hydraulic-fracturing/a-What-is-hydraulic-fracturing

ConocoPhillips. (2013, October 9). Submission, Parliament of Western Australia Environment and Public Affairs Committee, Inquiry into the Implications for Western Austrakia of Hydraulic Fracturing for Unconventional Gas. Perth, Western Australia.

Cook, P., Beck, V., Brereton, D., Clark, R., Fisher, B., Kentish, B., et al. (2013). *Engineering Energy: Unconventional Gas Production, A study of shale gas in Australia.* Melbourne: Australian Council of Learned Acadamies.

Corrs Chambers Westgarth. (2012, September 3). An Emerging new world for the Environmental Regulation of Unconventional Gas Projects in Western Australia. Perth, Western Australia.

Crawford School of Public Policy, Unconventional Gas Production and Water Resources, Lessons from the United States on better governance – a workshop for Australian government officials, 2012, pg 6 at https://crawford.anu.edu.au/pdf/inthenews/12186-unconventional-gas-document-web-fa.PDF

Department of Mines and Petroleum . (2013). *Environmental Risk Assessment of Chemicals used in WA Petroleum Activities Guideline.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2011). *Department of Mines and Petroleum Response to Report: 'Regulation of Shale, Coal Seam and Tight Gas Activities in Western Australia'.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2012). *Guidelines for the Preparation and Submission of an Environment Plan.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2013). *Chemical Disclosure Guideline* . Perth: Government of Western Australia.

Department of Mines and Petroleum. (2013). *Submission to the Legislative Council Standing Committee on Environment and Public Affairs: "Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2014). *Guidelines for the Petroleum and Geothermal Energy Resource (Resource Managent and Administration) Regulations 2014.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2014). *Natural Gas from Shale and Tight Rocks, 'An overview of Western Australia's regulatory framework'.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2014). *Western Australia's Petroleum and Geothermal Explorer's Guide 2014.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2015). *Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, A Whole of Government Approach.* Perth: Government of Western Australia.

Department of Mines and Petroleum. (2015, July). *Petroleum information sheet - Hydraulic fracture stimulation.* Retrieved December 10, 2015, from Department of Mines and Petroleum: www.dmp.wa.gov.au/shaleandtightgas

Department of Mines and Petroleum. (n.d.). *Guidelines for the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015.* Perth: Government of Western Australia.

Department of Mines and Petroleum, D (2016). *Guideline for the Development of Petroleum and Geothermal Environment Plans in Western Australia.* Perth: Department of Mines and Petroleum

Department of Mines and Petroleum. (n.d.). *Summary of comments and departmental responses from public consultation for new environment regulations. Petroleum and Geothermal Environment Regulations & Guidelines for Preparation and Submission of an Environment Plan.* Perth: Government of Western Australia.

Department of Water. (2009). *Industrial wastewater management and disposal.* Perth: Government of Western Australia.

Department of Water. (2013, October). Submission to the Legislative Council Standing Committee on Environment and Public Affairs. Perth, Western Australia.

Division of Water Resources, Department of Natural Resources. (n.d.). *Obtaining and Water Right.* Retrieved February 5, 2016, from Colorado Division of Water Resources, Department of Natural Resources: http://water.co.us/SurfaceWater/SWRights/Pages/HowGetWaterRights.aspx

Division of Water Resources, Department of Natural Resources. (n.d.). *Prior Appropriation Law.* Retrieved February 5, 2016, from Colorado Division of Water Resources, Department of Natural Resources: http://water.state.co.us/SurfaceWater/SWRights/Pages/PriorApprop.aspx

Dodd, Burwell, email to Patrick Dupont, Inquiry into Unconventional Gas and Fracking in SE of SA, 18 January 2015

Earthworks, 'Frack Fluids: Injected and Left Behind' (Fact Sheet), [accessed 1 May 2017] at http://earthworksaction.org/files/publications/FS_LeftBehind_lowres.pdf

Encana, Wellbore construction, from https://www.encana.com/sustainability/environment/water/protection/construction.html

Energy Resources Conservation Board. (20111). Unconventional Gas Regulatory Framework - Jurisdictional Review. Calgary: Energy Resources Conservation Board.

Energy Source, Why U.S Shale Gas will not be a Cookie Cutter Model (2012) [Online]. Energy Source Blog Spot

Energy, O. o. (2016). *Shale Research & Development, Unconventional Oil and Natural Gas*. Retrieved November 22, 2015, from http://www.energy.gov/fe/science-innovation/oil-gas-research/shale-gas-rd

Environmental Protection Authority. (2014). *Hydraulic Fracturing for onshore natural gas from shale and tight rocks.* Perth: Government of Western Australia.

Eshleman, K. N., & Elmore, A. (2013). *Recommended Best Management Practices for Marcellas Shale Gas Development in Maryland.* Frostburg: University of Maryland Center for Envirnmental Science.

Esq, S. N. (2012). Water Quality Regulations for Unconventional Gas Production, United States and Australia Comparison. Centennial , Colorado, United States.

Frac Focus Chemical Disclosure Registry, from <http://fracfocus.org/>

Frogtech Pty Ltd. (2013). Potential Geological Risks Associated with Shale Gas Production in Australia. Melbourne: Australian Council of Learned Academics.

Finley, B., Colorado Supreme Court Rules State Law Trumps Local Bans on Fracking, Denver Post, 2 May 2016 at www.denverpost.com/2-16/05/02/colorado-supreme-court-rules-law-trumps-local-bans-on-fracking

Gardner, A. (2013). Mining Access to Water Resources - Traditions and Developing Principles. *AMPLA Yearbook*, 306-339.

Gardner, A., Duff, N., Ainuson, K., & Manteaw, S. (2015). *Regulating Mining Water Use and Impacts in Ghana: Comparing Australian and Ghanaian Law for Reform Ideas.* Perth: International Mining for Development Centre.

General Electric Company. (2014). *A Menu of State Policy Good Practices for Uncontional Natural Gas Development.* General Electric Company.

Gething, A., Country Women's Association of Western Australia, Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, 15 August 2013

Geoscience News and Information. (2010). *What is Shale Gas?* Retrieved July 23, 2015, from http://geology.com/energy/shale-gas/

Geoscience News and Information. (2016). *Hydraulic Fracturing of Oil and Gas Wells Drilled in Shale*. Retrieved January 15, 2016, from http://geology.com/articles/hydraulic-fracturing/

Giurco, D. (2014). Responsible Mineral and Energy Futures: Views at the Nexus. *Journal of Cleaner Production*, 327.

Global Shale Gas and the Anti-Fracking Movement, Developing Union Perspective and Approaches, Working Paper 1, Trade Unions for Energy Democracy, [June 2014], pg 11 https://unionsforenergydemocracy.ord

Goodwin, S., Carlson, K., Knox, K., Douglas, C., & Rein, L. (2014). Water Intensity Assessment of Shale Gas Resources in the Wattenberg Field in Northern Eastern Colorado. *Environmental Science & Technology*, 5991-5995.

Goverment of Wetern Australia. (2015). *Response to Recommendations of the Legislative Council Standing Committee on Environment and Public Affairs Report No.42 Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas.* Perth: Government of Western Australia.

Gregory, K. B., Vidic, R. D., & Dzombak, D. A. (2011). Water Management Challenges Associated with the Production of Shale Gas by Hydraulic Fracturing. *Elements*, 181-186.

Groundwater Protection Council, from <http://www.gwpc.org/>

Guerra, K., Dahm, K., & Dundorf, S. (2011). *Oil and Gas Produced Water Management and Beneficial Use in the Western United States.* Denver: U.S. Department of the Interior.

Halliburton Australia Pty Ltd, Submission to the Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, 4 October 2013, pp 4-55 at < http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/570201DA298F66B048257C40000F617F/$file/ev.fra.131004.sub.106.halliburton.pdf>

Hawke, A. (2014). *Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory.* Darwin: Nothern Territory Government .

Hayes, J. (2012). Protecting Pennsyvania's Three River' Water Resources from Shale Gas Development Impacts. *Duke Environmental Law & Policy Forum*, 385-408.

Healy, J. (2012, September 5). For Farms in the West, Oil Wells Are Thirsty Rivals. *The New York Times*.

Hoeke, m. V. (2015). Methodology of Comparative Legal Research. *Law and Method*, 3.

Hoffman, A., Olsson, G., & Lindstrom, A. (2014). *Shale Gas and Hydraulic Fracturing - Framing the Water Issue.* Stockholm: Stockholm International Water Institute.

Hogan, M. (2012). Lessons from the West: Fracking and Water Resources. *Dividing the Waters* (pp. 1-12). Twins Falls, Idaho: UC Davis School of Law.

House, E.J., Fractured Fairytales: The Failed Social License for Unconventional Oil and Gas Development (2013) 13 WYO. L. Rev. 5, 51

Hunter, T. (2011). *Regulation of Shale, Coal Seam and Tight Gas Activities in Western Australia - Final.* Brisbane: Bond University.

Hunter, T. (2011). Shale Gas Resources in Western Australia: An Assessment of the Legal Framework. *Murdoch University Electronic Law Journal*, 29-52.

Hunter, T. (2014). Minimising the impact of shale and tight gas projects in Western Australia: an assessment of the existing regulatory framework. *APPEA Journal*, 83-90.

Hydraulic Fracturing: Unsafe, Unregulated, Public Citizen, Protecting Health, Safety and Democracy, from < https://www.citizen.org/our-work/climate-and-energy/hydraulic-fracturing-unsafe-unregulated>

IHS CERA Special Report. (2010). *Fuelling North America's Energy Future.* IHS CERA Inc.

Interstate Oil & Gas Compact Commission, from <http://iogcc.publishpath.com/>

International Energy Agency. (2012). *Annex of Regulation and Best Practice.* IEA.

International Energy Agency. (2012). *Golden Rules for a Golden Age of Gas - World Energy Outlook, Special Report on Unconventional Gas.* International Energy Agency.

Jarvis, M, 'Towards a Roadmap for Governance of Unconventional Gas: A Multidimensional Challenge' (2014) 12:3 Oil, Gas & Energy Law at < https://www.ogel.org/article.asp?key=3464> (assessed 23 November 2017)

Justin, email sent to Patrick Dupont, Inquiry into Unconventional Gas and Fracking in SE of SA, 19 January 2015

Keystone Exploration. (2015). *Natural Gas: Drilling*. Retrieved July 17, 2015, from <http://www.kx-kp.com/?page=drilling&type=natural_gas>

Konschnik, K. E., & Boling, M. K. (2014). Shale Gas Development: A Smart Regulation Framework. *Environmental Science & Technology*, A-M.

Kulander, C. S. (2013). Shale Oil and Gas State Regulatory Issues and Trends. *Case Western Review Law Review*, 1101-1141.

Kuwayama, Y., Roeshot, S., Krupnick, A., Richardson, N., & Mares, J. (2017). Risks and mitigation options for on-site storage of wastewater from shale gas and tight oil development. *Energy Policy*, 582-593.

Lacey, J., Parsons, R., & Moffat, K, Exploring the concept of a Social License to Operate in the Australian Minerals Industry, CSIRO 7 (2012), from < https://publications.csiro.au/rpr/download?pid=csiro:EP125553&dsid=DS3>

Lannin, S. (2014, February 11). WA Water Department tells inquiry it has no veto over shale gas fracking. *ABC News*.

Leather, D. T., Bahadori, A., Nwaoha, C., & Wood, D. A. (2013). A review of Australia's natural gas resources and their exploitation. *Journal of Natural Gas Science and Engineering*, 68-88.

Lutz, B. D., Lewis, A. N., & Doyle, M. W. (2013). Generation, transport, and disposal or wastewater assocaited with Marcellas Shale gas development. *Water Resources Research*, 1-10.

Maloney, K. O., & Yoxtheimer, D. A. (2012). Production and Disposal of Waste Materials for Gas and Oil Extraction from the Marcellas Shale Play in Pennsylvania. *Environmental Practice*, 278-287.

Marmion, B., Minister for Mines and Petroleum, 14 April 2015, p 4 to the Standing Committee on Environment and Public Affairs, Parliament of Western Australia, Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas, November 2015, pg 87 at <http://www.parliament.wa.gov.au/Parliament/commit.nsf/(Report+Lookup+by+Com+ID)/74E61E739E39E57748257EF9002150FE/$file/ev.fra.151117.rpf.042.xx.pdf>

Mayberry, J., email to Patrick Dupont, Inquiry into Unconventional Gas and Fracking in SE of SA, 12 January 2015

McGowan, M., Canning Basin agreement to be terminated, Wednesday, 29 November 2017 from < https://www.mediastatements.wa.gov.au/Pages/McGowan/2017/11/Canning-Basin-agreement-to-be-terminated.aspx>

Merrill, T. W., & Schizer, D. M. (2013). The Shale Oil and Gas Revolution, Hydaulic Fracturing and Water Contamination: A Regulatory Strategy. Minnesota Law Review, 206.

Minor, J. (2014). Local Government Fracking Regulations: A Colorado Case Study. *Stanford Environmental Law Journal*, 61-122.

Murray, T., Edward, A., & Prasad, K. (2016). Holding fracking operations to account for environmental contamination in risk-based regulatory regimes: Insights from the United States. *Environmental Planning Law Journal*, 222-236.

National Water Commission. (2014). *Water for mining and unconventional gas under the National Water Initiative.* Canberra: Commonwealth of Australia.

Natural Resources Committee. (2016). *Inquiry into Unconventional Gas (Fracking) in the South East of South Australia.* Adelaide: Parliament of South Australia.

Norton Rose Fulbright, Shale gas handbook, A quick-reference guide for companies involved in the exploitation of unconventional gas resources, June 2015 at http://www.nortonrosefulbright.com/files/norton-rose-fulbright-shale-gas-handbook-108992.pdf

Nicholson, B., & Blanson, K., Trends emerge on hydraulic fracturing litigation (2011) 109 *Oil and Gas Journal*

Oil and Gas, Oil and Gas Pooling, (accessed 12 June 2017) at http://www.oil-gas-leases.com/oil-gas-pooling.html

Olmstead, S., & Richardson, N. (2014). *Managing the Risks of Shale Gas Development Using Innovative Legal and Regulatory Approaches.* Washington, DC: Resources for the Future.

Onshore Oil and Gas Order, The Order, No.1, Onshore Oil and Gas Operations; Federal and Indian Oil and Gas Leases; Approval of Operations, 2007 at http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/onshore_order_videos.Par.62610.File.dat/Onshore_Order_No_1_The_Order.pdf

Ozwater Water Quality Regulations for Unconventional Gas, retrieved from https://www.ozwater.org/sites

Parsons, R., Lacey, J., & Moffat, K., Maintaining Legitimacy of a Contested Practice: How the Minerals Industry Understands its "Social License to Operate"' (2014) 41 Resources Policy 83, 84

Paul Reig, T. L. (2014). *Global Shale Gas Development, Water Availability and Business Risks.* Washington DC: World Resources Institute.

Petrol global news, 9 countries or regions that ban fracking, (assessed 1 January 2016) at https://petroglobalnews.com/2013/10/9-countries-or-regions-that-ban-fracking/amp

Prno, J., & Slocombe, S., Exploring the origins of "social license to operate" in the mining sector: Perspectives from governance and sustainability theories (2012) 37 *Resources Policy* 346, 347

Productivity Commission. (2013). Minerals and Energy Resource Exploration. Canberra: Australian Government.

Productivity Commission. (2013). *Non-Financial Barriers to Mineral and Energy Resource Exploration.* Canberra: Australian Government.

University of Colorado at Boulder, Southern Ute Tribe Laws, (accessed 15 June 2017) at http://www.oilandgasbmps.org/laws/tribal/southernute.php

University of Colorado at Boulder, Indian Law, (accessed 15 June 2017) at http://www.oilandgasbmps.org/laws/tribal/

Rahm, B. G., & Riha, S. J. (2014). Evolving shale gas management: water resource risks, impacts, and lessons learned. *Environ. Sci.:Processes*, 1400-1412.

Rawsthorn, K. (2013). *Shale Gas Prospectivity Potential.* AWT International.

Regulations, S. R. (2011). *Colorado Hydraulic Fracturing State Review.* Colorado: STRONGER.

Reins, L. (2011). The Shale Gas Extraction Process and its Impacts on Water Resources. *Review of European Community & International Environmental Law*, 300-312.

Richardson, N., Gottlieb, M., Krupnick, A., & Wiseman, H. (2013). *The State of State Shale Gas Regulation.* Washington, DC: Resources for the Future.

Rickson, D., Chairman Gingin Water Group, Submission, Inquiry into the Implications for W.A of Hydraulic Fracturing for Unconventional Gas, 19 September 2013

Richert, C., Rogers, A., & Burton, M. (2015). Measuring the Extent of a Social Licence to Operate: The Influence of Marine Biodiversity in the Oil and Gas Sector in Western Australia. *Resources Policy*, 121.

Robb, S. (2014). A Best Practice Regulatory Approach for Shale Gas Production. Perth: University of Western Australia.

Romo, C. R., & Cagle, M. (2014, March/April). State Policy and technological innovation in hydraulic fracturing water management. *ABA Section Environment, Energy, and Resources*, pp. 1-4.

Romo, C. R., & Janoe, J. S. (2012). Regulatory Regimes for Recycling Produced and Frac Flowback Water. Austin, Texas, United States of America.

Roost, H. (2013, May 15). The Regulation of Unconventional Petroleum Exploration and Production in Western Australia. Perth, Western Australia.

Ross, C., & Paige Darby. (2013). *Unconventional Gas: Coal Seam Gas, Shale Gas and Tight Gas, An introduction and overview of issue relevant to the development of unconventional gas in Victoria.* Victoria: Parliament of Victoria.

Ross, C., Mudd, G. M., St John, A., Lesman, B., & Macreadie, R. (2013). *Unconventional Gas: Coal Seam Gas, Shale Gas and Tight Gas.* Victoria: Parliament of Victoria.

Rothstein, H., Irving, P., Walden, T., & Yearsley, R., 'The risks of risk-based regulation: Insights from the environmental policy domain' (2006) 32 Environmental International 1056, 1061

Rutovitz, J., Harris, S., Kuruppu, N., & Dunstan, C. (2011). *Drilling Down. Coal Seam Gas: A background papaper.* Sydney: Institute for Sunstainable Futures.

Santos. (2013, October 4). Parliamentary Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas. Perth, Western Australia.

Santos, SA Cooper Basin, Environmental Impact Report: Drilling, Completions and Well Operations, November 2015 from https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PGER00245EIR%20DRILLING%20OPERATIONS.pdf>

Santos, Moomba 191 and Beyond, 28 August 2013 at http://www.santos.com/library/130828_Moomba_191_and_beyond.pdf

Schlumberger, Oilfield Glossary, 'Drill String', from http://www.glossary.oilfield.slb.com/Terms/d/drill_string.aspx

Shaffer, A., Zilliox, S., & Smith, J., Memoranda of understanding and the social licence to operate in Colorado's unconventional energy industry: a study of citizen complaints (2017) 35:1 *Journal of Energy & Natural Resources Law*, 69, 73

Shale Gas Information Platform. (2015). *What are the risks?* Retrieved June 17, 2015, from http://www.shale-gas-information-platform.org/what-are-the-risks.html

Shale Gas Round Table. (2013). *Water and Unconventional Oil and Gas* . Shale Gas Round Table.

Smith, D. C., & Richards, J. (2015). *Social Licence to Operate: Hydraulic Fracturing-Related Challenges Facing the Oil & Gas Industry.* Denver: Sturm College of Law.

State Review of Oil & Natural Gas Environmental Regulations Inc. (2014). *2014 Stronger Guidelines.* STRONGER.

Sturmer, M, Submission, Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 18 August 2013

Southern Ute Indian Tribe Growth Fund Department of Energy, The Exploration & Production Operator's Compliance Manual for Energy Development Projects on the Southern Ute Indian Reservation, (15 March 2018) at http://www.suitdoe.com/Documents/EPOperatorsComplianceManual.pdf

Ternes, M. E. (2012). Regulatory Programs Governing Shale Gas Development. *American Institute of Chemical Engineers*, 60-64.

The Pennsylvania State University. (2011, April). Marcellus Shale Wastewater Issues in Pennsylvania - Current and Emerging Treatment and Disposal Technologies. *Penn State Extension*, pp. 1-9.

The Rifle, Silt, New Castle Community Development Plan A Collaborative Planning Document between the RSNC Defined Area Residents, Antero Resources Corp. and Galaxy Energy, 2006, pg 12 at http://www.oilandgasbmps.org/docs/CO68-RSNCCommunityDevelopmentPlan.pdf

The Standing Committee on Environment and Public Affairs. (2013, October). Submission to the Legislative Council Standing Committee on Environment and Public Affairs. Perth, Western Australia.

The Standing Committee on Environment and Public Affairs. (2014, February 7). Transcript of Evidence - APPEA. Perth, Western Australia.

The Standing Committee on Environment and Public Affairs. (2014, October 7). Transcript of Evidence - Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas. Perth, Western Australia.

The Standing Committee on Environment and Public Affairs. (2015). *Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas.* Perth: Parliament of Western Australia.

The Standing Council on Energy and Resources. (2013). *The National Harmonised Regulatory Framework for Natural Gas from Coal Seams.* Canberra: Coucil of Australian Governments.

Thrower J, 'Adaptive Management and NEPA: How a Nonequilibrium View of Ecosystems Mandates Flexible Regulation' (2006) 33 Ecology Law Quarterly 871, 873.

Tiemann, M., & Vann, A. (2013). *Hydraulic Fracturing and Safe Drinking Water Regulatory Issues.* Washington, DC: Congressional Research Service.

Tiemann, M., Andrews, A., Copeland, C., Folger, P., Brougher, C., & Meltz, R. (2012). *Marcellas Shale Gas: Development Potential and Water Management Issues and Laws.* Washington, DC: Congressional Research Service.

Tiemann, M., Folger, P., & Carter, N. T. (2014). *Shale Energy Technology Assessment: Current and Emerging Water Practices.* Washington, DC: Congressional Research Service.

Toan, K. (2015). Not Under My Backyard: The Battle Between Colorado and Local Governments Over Hydraulic Fracturing. *Colo. Nat. Resources, Energy & Envtl. L. Rev*, 1-67.

Triche, D. N. (2015). Unconventional Resources: Applying the World To (Western Australia). Perth: Department of Mines and Petroleum

UCL International Energy Policy Institute Adelaide, Australia, Shale Gas in Australia: The Policy Options, Green Paper, October 2013, pg 4 from https://www.ucl.ac.uk/australia/files/shale-gas-in-australia-green-paper-final

U.S Energy Information Administration. (2014). *Australia, International Energy Data and Analysis.* Washington DC: Office of Energy.

U.S Energy Information Administration. (2015). *Technically Recoverable Shale Oil and Shale Gas Resources.* Washington DC: U.S Department of Energy.

U.S. Energy Information Administration. (2011). *Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays: Analysis and Projections.* Washington DC: U.S. Department of Energy.

U.S. Energy Information Administration. (2016). *Energy in Brief - Shale in the United States*. Retrieved January 15, 2016, from http://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm

UIL Energy. (2013, September 19). Re: Inquiry into the implications for Western Australia of hydraulic fracturing for unconventional gas. Perth, Western Australia.

University of Colorado at Boulder. (n.d.). *Colorado Laws.* Retrieved May 17, 2017, from Intermountain Oil and Gas BMP Project: http://www.oilandgasbmps.org/laws/colorado_law.php

University of Colorado at Boulder. (n.d.). *Hydraulic Fracturing.* Retrieved May 7, 2015, from Intermountain Oil and Gas BMP Project: http://www.oilandgasbmps.org/resources/fracing.php

Vidic, R. D., Brantley, S. L., Vandenbossche, J. M., Yoxtheimer, D., & Abad, J. D. (2013). Impact of Shale Gas Development on Regional Water Quality. *Science*, 826-835.

Wang, Z., & Krupnick, A., A Retrospective Review of Shale Gas Development in the United States: What Led t the Boom? 2013 at http://www.rff.org/RFF/Documents/RFF-DP-13-12.pdf

Warner, N. R., Christie, C. A., Jackson, R. B., & Vengosh, A. (2013). Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania. *Environmental Science & Technology*, 11849-11857.

Water Corporation. (2013, September). Water Corporation Submission to the Standing Committee on Environment and Public Affairs - Inquiry into the Implications for Western Australia of Hydraulic Fractruing for Unconventional Gas. Perth, Western Australia.

Water Well Construction Rules at http://water.state.co.us/DWRIPub/Documents/gws-09.pdf

Whitehead, E., Submission, Inquiry in the Implications for W.A. of Hydraulic Fracturing for Unconventional Gas, 11 September 2013

Wilson, A., Regnan, Submission, Inquiry into the Implications of Hydraulic Fracturing for Unconventional Gas, 17 September 2013

Wines, M., Colorado Court Strikes Down Local Bans on Fracking, *The New York Times, 2 May 2016, from* https://mobile.nytimes.com/2016/05/03/us/colorado-court-strikes-down-local-bans-on-fracking.html

Wiseman, H., & Gradijan, F. (2012). *Regulation of Shale Gas Development, Including Hydraulic Fracturing.* Tulsa: University of Tulsa.