



THIRTY-NINTH PARLIAMENT

REPORT 42

**STANDING COMMITTEE ON ENVIRONMENT AND
PUBLIC AFFAIRS**

**IMPLICATIONS FOR WESTERN AUSTRALIA
OF HYDRAULIC FRACTURING FOR
UNCONVENTIONAL GAS**

Presented by Hon Simon O'Brien MLC (Chairman)

November 2015

STANDING COMMITTEE ON ENVIRONMENT AND PUBLIC AFFAIRS

Date first appointed:

17 August 2005

Terms of Reference:

The following is an extract from Schedule 1 of the Legislative Council Standing Orders:

“2. Environment and Public Affairs Committee

- 2.1 An *Environment and Public Affairs Committee* is established.
- 2.2 The Committee consists of 5 Members.
- 2.3 The functions of the Committee are to inquire into and report on –
 - (a) any public or private policy, practice, scheme, arrangement, or project whose implementation, or intended implementation, within the limits of the State is affecting, or may affect, the environment;
 - (b) any bill referred by the Council; and
 - (c) petitions.
- 2.4 The Committee, where relevant and appropriate, is to assess the merit of matters or issues arising from an inquiry in accordance with the principles of ecologically sustainable development and the minimisation of harm to the environment.
- 2.5 The Committee may refer a petition to another Committee where the subject matter of the petition is within the competence of that Committee.
- 2.6 In this order **“environment”** has the meaning assigned to it under section 3(1), (2) of the *Environmental Protection Act 1986*.”

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Glossary

Adsorption	The adhesion of atoms or molecules to the surface of a material.
ALARP	‘As Low as Reasonably Practicable.’ A term used as part of a risk or safety assessment in industry or government. May require a balancing of the particular hazard against other factors, such as the cost of reducing risk to zero.
Annulus	The space between two concentric objects, such as between the wellbore and casing or between casing and tubing, where fluid can flow.
Baseline survey	Data collection undertaken prior to operations commencing to determine the natural background levels of certain substances and/or natural geology of an area.
Biocide	Chemical agent used to control or destroy living organisms (bacteria), often for the purposes of disinfection.
Biogenic methane	Naturally-occurring methane in the environment, caused by the breakdown of organisms (‘biogenic’ meaning produced by bacteria).
Blowout	A sudden and uncontrolled escape of fluids or gas from a well to the surface, often caused by a pocket of high pressure in the formation. Also known as a ‘catastrophic well failure.’
Borehole	The hole drilled into the earth to obtain natural gas or oil. Also called a ‘wellbore.’
Breaker	A chemical additive that reduces the viscosity of fluids by breaking long-chain molecules into shorter segments.
BTEX	Group of volatile chemical compounds including benzene, toluene, ethylbenzene and xylenes, found deep underground and in oil. BTEX chemicals can be used during hydraulic fracturing, or can rise to the surface as a result of the process.
Cap rock	An impermeable layer of rock lying above and sealing in a reservoir of gas or oil.
Casing	Metal pipe placed in a well to prevent the walls of the hole from collapsing and to prevent movement of fluids across subterranean geological formations. Also maintains control of fluid and pressure during drilling.
Casing string	Pipe that lines a well after it has been drilled. Formed from sections of tube fastened together with screws.
Cement bond log	An acoustic device run inside casings to detect the presence of cement, according to the absorption or reflection of transmitted sound signals. Used to test if cement is adhering effectively to both sides of the annulus between casings or between the outer casing and sides of the rock.

Christmas tree	Industry term for the set of valves, spools and fittings connected to the above-ground portion of a well that controls flow of gas from wellbore.
Coal seam gas	Natural gas (refer to 'methane' definition) that is extracted from coal seams underground. Coal seams occur very close to the surface and often near aquifers. Also known as 'coalbed methane' or 'CSG.'
Condensate	Low density, high energy content liquid hydrocarbon that generally occurs in association with natural gas. Gas that is produced in association with condensate is called 'wet gas.'
Darcy	A unit used to calculate permeability, which is the ability of fluids to flow through solids.
Depocentre	Site of maximum thickness of sediment accumulation in a sedimentary basin over a particular period of time.
Devonian period	A geological time period of the late Palaeozoic era, between approximately 416 and 362 million years ago.
Flowback	Fluid that is returned to the surface after hydraulic stimulation of a well. It will contain oil or gas, the original chemicals, produced water and NORM (refer to 'NORM' below). See also 'produced water' definition.
Fossil fuel	Fuel such as oil, natural gas and coal which was formed from the decomposition of organic materials that lived millions of years ago.
Fracking/fraccing	Shorthand term used to describe hydraulic fracturing (refer to 'hydraulic fracturing' definition).
Fugitive methane	Methane that escapes into the atmosphere. May be released by venting or flaring of the gas or from a migration or leak.
GHG	Abbreviation for 'greenhouse gases', which are gases that trap heat in the atmosphere. The four main GHG are carbon dioxide, methane, nitrous oxide and fluorinated gases (synthetic GHG emitted from industrial processes).
Gooseneck	An inverted U-shaped section of rigid pipe used to deliver high-pressure drilling fluid.
Horizontal drilling	The process by which wells are drilled horizontally using specialised drill bits (after being drilled vertically to the desired depth) to access gas or oil reservoirs not otherwise accessible. Also called 'directional drilling' or 'deviated drilling', where the wellbore is intentionally deviated from the path that it would naturally take.
Hydraulic fracturing	The process of extracting gas or oil by pumping fluid (usually water, but can be other liquids) and various chemicals at high pressure into a formation to fracture the rock formation and release the hydrocarbons contained within.
Induced seismicity	Seismic (earthquake) activity that is a result of human activity, including the injection of water or other fluids into the earth, which can increase

the fluid pressure in a fault zone, leading to a seismic event.

Methane	Organic compound comprised of hydrogen and carbon with the chemical formula CH ₄ , found naturally in the environment and in geological formations. Colourless, odourless gas which is the chief component of natural gas. Natural gas with a high concentration of methane is known as 'dry gas' (such as coal seam gas) whilst that with a high proportion of C ₂ to C ₅ hydrocarbons is known as 'wet gas' (refer to 'condensate' definition).
Multi-stage drilling	Can refer to either multiple wells drilled from the same pad ('multi-well pad drilling') or to multi-stage fracture stimulation, where more than one fracture is created along the wellbore, either in vertical or horizontal wells.
NORM	Naturally Occurring Radioactive Materials.
Orphan well	An abandoned well, pipeline or associated site for which either no party claims responsibility (legally or financially) or an owner cannot be found.
PDWSA	Public Drinking Water Source Area.
Perforating gun	Used to pierce holes in the casing and cement in a well to allow formation fluids, including gas, to enter the well and, in turn, to allow fluids to be injected into a geological formation at pressure.
Permeability	The rate at which a liquid or gas flows through porous material.
Petroleum	Defined in the <i>Petroleum and Geothermal Energy Resources Act 1967</i> : 'petroleum' means any naturally occurring hydrocarbon or mixture of hydrocarbons, whether in a gaseous, liquid or solid state and includes any of the above that has been returned to a natural reservoir, but excludes oil shale.
Plug & abandon	(or 'P&A') Industry term for the process of preparing a well to be closed permanently, usually after either monitoring has determined that there is insufficient oil or gas potential to complete the well or after production operations have drained the reservoir. The term 'decommissioning' is used interchangeably.
Porosity	The ratio of the fraction of voids (empty spaces) to the volume of rock in which they occur.
Produced water	Water that is a byproduct of hydrocarbon extraction, consisting mostly of water (often briny or brackish) contained in a formation, but can also include slickwater (refer also to 'flowback' definition).
Production casing	Casing string set near the bottom of a completed borehole through which natural gas or oil is produced.

Proppant	Solid material, often silica, ceramic beads or other granular substance, used to hold open the fractures in rock caused by hydraulic fracturing. Proppant is carried in suspension in the fracturing fluid and its function is to hold open fractures that occur in the formation when the fracturing fluid is withdrawn after perforation.
Reserve	Industry term used to define a gas deposit that has been extensively drilled and quantified such that it is likely economic to extract. ‘1P’ reserves are proved; ‘2P’ reserves are proved and probable; and ‘3P’ reserves are proved, probable and possible (being the most certain and commercially viable for extraction).
Resource	Quantity of gas in the field that is poorly known or explored and possibly uneconomic to extract (unless it becomes a ‘reserve’).
Self-healing cement	Commercial cement product developed by Halliburton (proprietary names include LifeCem™ and LifeSeal™) which expands upon reaction with migrating fluids within the casing string, thereby sealing the flow path and preventing further fluid leaks through the cement.
Shale	Organically-rich sedimentary rock, with very fine grains in many tiny layers and therefore with very low permeability.
Shale gas	Natural gas trapped between the layers of shale deep underground. Shale gas usually occurs at depths exceeding 1000 metres underground.
Shale play	The area of a shale basin where gas (or oil) could be commercially extracted. Areas with better production potential within a play are known as the ‘sweet spot’ or ‘core area.’
Slickwater	Fracturing technique used where fluid contains high volumes of water, as well as proppant and chemicals, usually containing cross-linked polymers to reduce friction to better enable gas to flow.
Spud (verb)	Industry term used to mean the start of drilling on a new well. Also used to refer to various processes related to spudding of the well, including the ‘spud date’ and ‘spud time.’
Tight gas	Natural gas (refer to ‘methane’ definition) that is trapped in low permeability and low porosity reservoir rocks, such as sandstone and limestone.
tcf	‘trillion cubic feet’, used to measure volume (of gas). A trillion is a million times a million or 10^{12} (originally USA but now also accepted in UK and Australia).
Turkey’s nest	Industry term for onsite water storage pit, so called because it resembles a bush turkey’s nest. Also called ‘water pit.’
Unconventional gas	Natural gas found in impermeable rock formations which cannot migrate to a specific area to form a conventional gas deposit. Types of unconventional gas include shale gas, coal seam gas/coal bed methane or

tight gas. The type of rock and how the gas is trapped defines whether natural gas is referred to as 'conventional gas' or 'unconventional gas.'

Wellhead	The equipment at the surface above the well. Refer also to 'Christmas tree' definition.
Wildcatter	Industry term that originated in the USA to describe a prospector who drills wells for gas or oil in areas not known to be productive. Can also describe the well itself (a 'wildcat well').
Workover	The process of repeat hydraulic fracturing on a particular well, sometimes over a period of years to encourage greater gas flow.
3D/2D seismic	Imaging of subsurface structures and geology in either three or two dimensions using reflective seismology (seismic or acoustic waves). Used to locate existing faults or hydrocarbon deposits, often very deep underground, or to map underground aquifers.

Government Response

This Report is subject to Standing Order 191(1):

Where a report recommends action by, or seeks a response from, the Government, the responsible Minister or Leader of the House shall provide its response to the Council within not more than 2 months or at the earliest opportunity after that time if the Council is adjourned or in recess.

The two-month period commences on the date of tabling.

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EXECUTIVE SUMMARY, FINDINGS AND RECOMMENDATIONS

EXECUTIVE SUMMARY

- 1 The Standing Committee on Environment and Public Affairs (**Committee**) identified in August 2013 that the emergence of an unconventional gas industry in Western Australia was a source of community interest and concern.
- 2 We resolved to investigate hydraulic fracturing and its implications for our State, with particular emphasis on environmental considerations. This report is the culmination of two years of evidence gathering, research and engagement with the community through public hearings and submissions.
- 3 The Committee examined both operational and decommissioned well sites where hydraulic fracturing has occurred, giving a privileged insight into the current and potential future impact of unconventional gas mining on the Western Australian landscape.
- 4 Through public submissions and hearings, we have learnt that issues such as the protection of groundwater, chemical disclosure requirements and obtaining a social licence to operate are universal concerns when discussing hydraulic fracturing, which has led the Committee to benefit from lessons learned in other jurisdictions.
- 5 Energy security is a major priority for governments and the rapid development of the shale gas industry has been variously described as a ‘revolution,’ a ‘paradigm shift,’ a ‘boom’ and a ‘golden age.’ These phrases, however, have been used to describe the push towards natural gas in the United States of America (**USA**) and may not be as relevant to our situation in Western Australia as originally predicted.
- 6 Hydraulic fracturing is the technology whereby fluid is forced at high pressure into a geological formation that contains oil or gas so that the flow is stimulated and it can be extracted more easily. It is not a new process and has been used for many decades; the difference is the type of fluids used, how much pressure is applied and how the well is drilled.
- 7 Global interest in the use of hydraulic fracturing to extract unconventional gas has, however, been accompanied by controversy. Communities have been polarised by the question of whether resource companies should be allowed to use hydraulic fracturing on wells if there is a risk of any damage to the environment, property or human health.
- 8 There are differing, and often competing views, about the level and likelihood of risks related to hydraulic fracturing: proponents of the technology argue that many risks are exaggerated, whilst opponents of hydraulic fracturing refer to the ‘precautionary

principle' and that, if there is any risk whatsoever then hydraulic fracturing should be prohibited.

- 9 The Committee has formed the view during the course of this inquiry that the truth lies somewhere between these two views and the purpose of this report is to present the Committee's findings of fact, free from bias and any irrelevant considerations.
- 10 The Committee notes that a recent CSIRO report found that Australians broadly accept mining, with a reasonably positive acceptance of the industry. The same survey, however, revealed a low level of trust of both industry and regulators amongst the community.
- 11 Through its inquiries, the Committee has found that it is imperative to engage with affected communities early in the process of developing an unconventional gas industry in a region. Operators and regulators must be informative, upfront and candid when consulting with the public.
- 12 Governments need to ensure that policy-making acknowledges the inherent risk in energy production and if a decision is made to proceed with exploration and development that the reasons for this are easily understood. This will ensure that any policy decision to permit or to ban hydraulic fracturing can withstand robust scrutiny.
- 13 The purpose of this inquiry has been to provide a comprehensive body of factual information and findings to assist the Parliament of Western Australia, future decision makers and the public in their contemplation of this industry.
- 14 The Committee notes that there is a need for an informed debate on hydraulic fracturing and further scientific study in some areas and is confident that this multi-party standing committee of the Legislative Council of Western Australia has contributed constructively to the debate with this report.

FINDINGS AND RECOMMENDATIONS

- 15 Recommendations are grouped as they appear in the text at the page number indicated:

Page 26

Finding 1: The Committee finds that when horizontal drilling and multi-well pad technology are used during hydraulic fracturing for unconventional gas, the surface footprint of the process is decreased, therefore also minimising the environmental impact of hydraulic fracturing.

Page 37

Finding 2: The Committee finds that, prior to the commencement of this inquiry, the Department of Mines and Petroleum had taken action to assess the readiness of the agency to deal effectively with the regulation of the onshore shale gas industry, including exploration and production and took action to strengthen its regulatory framework for onshore gas exploration.

Page 37

Finding 3: The Committee finds that, during the course of this inquiry, the management of well activities, including field management plans and the requirements for baseline monitoring, as set out in the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 has improved, which is a positive development in the regulation of onshore gas activities and hydraulic fracturing in Western Australia.

Page 38

Finding 4: The Committee finds that the information required in environment plans lodged pursuant to regulation 14 of the Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 is important baseline information which is essential to regulate any ongoing effects of hydraulic fracturing on the environment.

Page 40

Finding 5: The Committee finds that the current penalties included in the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015, which range from penalties of \$4000 to a maximum of \$10 000, are not adequate to effectively deter the behaviour outlined in the regulations.

Page 40

Recommendation 1: The Committee recommends that the Government amend section 153(3) of the *Petroleum and Geothermal Energy Resources Act 1967* to increase the maximum fines permitted in regulations made under the Act to a more appropriate level.

Page 43

Finding 6: The Committee finds that Part 9 of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015, in particular regulation 83, does not meet the Department of Mines and Petroleum's stated intention of transparent and open communication and engagement with the public regarding hydraulic fracturing in this State.

Page 43

Recommendation 2: The Committee recommends that regulation 83 of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 be amended, in particular the deletion of regulations 83(4) and 83(5).

Page 45

Finding 7: The Committee finds that the Department of Mines and Petroleum has improved its monitoring and compliance activities following the Auditor General's 2011 report, 'Ensuring Compliance with Conditions on Mining', that had found deficiencies in its compliance with conditions on mining.

Page 53

Finding 8: The Committee finds that there is an inconsistency between the terms of referral in the Memorandum of Understanding between the Department of Mines and Petroleum and the Environmental Protection Authority and the informal interagency discussions which take place prior to proposals being referred under section 38 of the *Environmental Protection Act 1986*.

Page 53

Recommendation 3: The Committee recommends that the Memorandum of Understanding between the Department of Mines and Petroleum and the Environmental Protection Agency be amended to require the Department of Mines and Petroleum to refer all proposals under section 38 of the *Environmental Protection Act 1986* to the Environmental Protection Agency.

Page 56

Finding 9: The Committee finds that the Environmental Protection Authority's process of assessing proposals according to the *Environmental Protection Act 1986* is well-established and satisfies the legislative requirements of section 38 of the Act and its role as an advisory agency to the Minister for the Environment.

Page 56

Finding 10: The Committee finds that the Environmental Protection Authority has a mature understanding of its statutory obligations and that, during the course of this inquiry, the agency has set in place procedures to better explain its role to the community.

Page 57

Finding 11: The Committee finds that the decision by the Environmental Protection Authority to not conduct a formal assessment of a proposal pursuant to the requirements of section 38 of the *Environmental Protection Act 1986* is a decision pursuant to that statute.

Page 59

Finding 12: The Committee finds that, whilst the agreement between the Department of Water and the Department of Mines and Petroleum is primarily administrative in its content, it is a positive development in the interagency regulation of the unconventional gas industry in Western Australia.

Page 62

Finding 13: The Committee finds that there are sufficient safeguards and water source protection policies in place to protect Public Drinking Water Source Areas in Western Australia without the introduction of a 1.5 kilometre buffer zone between water source areas and unconventional gas activity.

Page 62

Finding 14: The Committee finds that the Department of Water is acutely aware of the importance of protecting Public Drinking Water Source Areas and their integrity in Western Australia and is addressing this issue proactively through measures such as the new administrative agreement with the Department of Mines and Petroleum.

Page 63

Recommendation 4: The Committee recommends that the Department of Mines and Petroleum develop a mechanism to consult with the Water Corporation (or, in the case of regional areas, with the relevant water provider) in relation to the regulation of hydraulic fracturing activities.

Page 68

Finding 15: The Committee finds that the Department of Health's *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supply areas: Human Health Risk Assessment* is an important document in informing the public debate about hydraulic fracturing.

Page 80

Finding 16: The Committee finds that the Australian Petroleum Production and Exploration Association Limited's Land Access Roundtable is a worthy initiative to bring land owners and resource companies to the negotiating table with regard to land access, but more needs to be done to ensure that land owners' rights are protected.

Page 83

Finding 17: The Committee finds that it is a fundamental expectation of the Australian community that a resource company must negotiate with a land owner before seeking to enter onto their land.

Page 84

Finding 18: The Committee finds that the relative bargaining strength of a landowner compared with a resource company is a significant issue in all jurisdictions.

Page 84

Finding 19: The Committee finds that land owners and resource companies should be encouraged to negotiate land access agreements through the use of alternative dispute resolution methods, rather than seeking redress through the court system.

Page 84

Finding 20: The Committee finds that resource companies should be liable to pay for the reasonable legal and other associated costs of land owners during negotiations for land access.

Page 86

Finding 21: The Committee finds that the establishment of an independent statutory body is the most appropriate means to address the inequity in bargaining power between land owners and resource companies during negotiations for access to land.

Page 87

Recommendation 5: The Committee recommends that the Government establish a statutory body similar to the Queensland GasFields Commission to act as an independent arbiter for land owners and resource companies in land access negotiations involving onshore shale gas.

Page 87

Recommendation 6: The Committee recommends that the Government establish a working group, including land owner representatives and community leaders, to draft legislation for a statutory framework for land access agreements between land owners and resource companies. The framework should include provisions for an agreement template, compensation for land owners and the enforcement of mandatory access conditions using Queensland's Land Access Code as a guide.

Page 102

Finding 22: The Committee finds that Western Australia's requirements for operators to use a minimum of three casing strings during drilling represents international best practice in the onshore gas industry.

Page 102

Finding 23: The Committee finds that it is beneficial for Western Australian regulators and operators to look to unconventional gas industries in other jurisdictions and learn from the more established stakeholders in the global shale gas market.

Page 107

Finding 24: The Committee finds that, whilst the amount of chemicals used in hydraulic fracturing fluid can be very large, the proportion of chemical to water and proppant is heavily diluted.

Page 110

Finding 25: The Committee finds that the use of benzene, toluene, ethylbenzene and xylene during hydraulic fracturing poses an unacceptable and unnecessary risk to the environment and to human health.

Page 110

Recommendation 7: The Committee recommends that the Government ban the use of benzene, toluene, ethylbenzene and xylene during any hydraulic fracturing operations undertaken in Western Australia.

Page 113

Finding 26: The Committee finds that the perceived secrecy surrounding the details of chemicals used by resource companies during hydraulic fracturing operations is a very important issue in the community and must be addressed.

Page 113

Recommendation 8: The Committee recommends that the Department of Mines and Petroleum's policy of public disclosure of chemicals used in any hydraulic fracturing activity be formalised in subsidiary legislation.

Page 130

Finding 27: The Committee finds that there are significant environmental and financial benefits that may accrue to operators from the use of recycled wastewater during hydraulic fracturing.

Page 130

Recommendation 9: The Committee recommends that resource companies in Western Australia be encouraged to explore the recycling of wastewater during hydraulic fracturing operations, where practicable.

Page 131

Finding 28: The Committee finds that the Government should encourage resource companies to investigate alternatives to fresh water use during hydraulic fracturing, including the use of water from saline aquifers, with a view to reducing the reliance upon fresh water for hydraulic fracturing operations.

Page 134

Finding 29: The Committee finds that the likelihood of hydraulic fractures intersecting underground aquifers is negligible.

Page 135

Finding 30: The Committee finds that the risk of spills of chemicals or other fluids associated with hydraulic fracturing can be effectively managed in Western Australia through the environmental requirements in the Petroleum and Geothermal Resources (Environment) Regulations 2012.

Page 137

Finding 31: The Committee finds that the risk of water contamination as a result of fugitive methane during hydraulic fracturing in Western Australia is highly unlikely and can be minimised through baseline monitoring of water quality and ongoing monitoring pursuant to the Petroleum and Geothermal Energy Resources (Environment) Regulations 2012.

Page 137

Finding 32: The Committee finds that the risk of fugitive methane relative to the total number of wells is very low and can be adequately managed.

Page 137

Finding 33: The Committee finds that baseline water quality monitoring to measure any presence of methane in water sources is essential to ensure that water sources are protected from contamination.

Page 137

Recommendation 10: The Committee recommends that baseline monitoring of aquifers and the subsequent publication of this data be a mandatory condition of all approvals for hydraulic fracturing operations in Western Australia.

Page 143

Finding 34: The Committee finds that many of the concerns expressed by the community in relation to the impact of hydraulic fracturing for unconventional gas can be addressed through robust regulation and ongoing monitoring.

Page 143

Finding 35: The Committee finds that the statement that the development of the unconventional gas industry in Western Australia will result in thousands of wells in the Kimberley and the Midwest has been over-stated and is not based on evidence.

Page 143

Finding 36: The Committee finds that the cumulative impact of the number of shale gas wells is an important factor in assessing the ongoing impact of hydraulic fracturing on land.

Page 145

Finding 37: The Committee finds that it is important to recognise that there is mistrust and confusion in the community due to the different definitions of well failure.

Page 149

Finding 38: The Committee finds that a well failure does not necessarily result in a leak to the external environment, therefore it is incorrect to equate all well failures with environmental impacts.

Page 150

Finding 39: The Committee finds that Western Australian best practice in well design and construction means that it is more meaningful to refer to a well failure having an impact on the environment when the well failure results in a leak path to the environment. According to evidence from the Department of Mines and Petroleum, there have been no failures of surface or conductor casings.

Page 152

Finding 40: The Committee finds that, whilst there are some international jurisdictions where lost or orphan wells continue to have an impact on the environment, in contrast, Western Australia has a robust system in place for the monitoring of abandoned wells that begins prior to any petroleum activity taking place.

Page 155

Finding 41: The Committee finds that the Mining Rehabilitation Fund that applies to tenements issued under the *Mining Act 1978* is a positive development in the ongoing rehabilitation of land used for mining activities.

Page 155

Recommendation 11: The Committee recommends that a fund similar to the Mining Rehabilitation Fund under the *Mining Rehabilitation Fund Act 2012* be established for activities governed by the *Petroleum and Geothermal Energy Act 1967*.

Page 161

Finding 42: The Committee finds that the risk of induced seismicity associated with hydraulic fracturing of shale plays at depth is negligible.

Page 161

Finding 43: The Committee finds that the Department of Mines and Petroleum's policy of not permitting reinjection of wastewater into aquifers has merit and is supported.

Page 161

Finding 44: The Committee finds that reinjection should not generally be the preferred option for the disposal of wastewater during hydraulic fracturing operations.

Page 163

Finding 45: The Committee finds that, given Western Australia's geology and low background seismicity, the State is unlikely to experience any negative effects from induced seismicity as a result of hydraulic fracturing.

Page 164

Finding 46: The Committee finds that the risk of induced seismicity linked to hydraulic fracturing can be effectively reduced by implementing mitigation strategies and using baseline data to monitor seismicity before, during and after any hydraulic fracturing activities.

Page 164

Finding 47: The Committee finds that a traffic light monitoring system for induced seismic events related to hydraulic fracturing has merit, but is unlikely to be necessary in Western Australia.

Page 170

Finding 48: The Committee finds that ongoing consultation with the community is essential for a continued social licence to exist, as the nature of unconventional gas development is such that one-off consultation is ineffective.

Page 175

Finding 49: The Committee finds that the views of those communities directly affected by hydraulic fracturing operations should hold significant weight in any decision-making related to the development of an unconventional gas industry in Western Australia.

Page 176

Finding 50: The Committee finds that baseline monitoring of water sources and local geology is fundamentally important, not only for scientific purposes, but also to establish a successful social licence for unconventional gas development.

Page 176

Finding 51: The Committee finds that transparency in data and effective communication to the public of information related to hydraulic fracturing is vital to establish a successful social licence for unconventional gas development.

Page 177

Recommendation 12: The Committee recommends that any future consideration of hydraulic fracturing for unconventional gas in Western Australia be based on established facts, ascertained through baseline data and monitoring, with a view to strengthening the industry's social licence to operate.

CHAPTER 1

INTRODUCTION

INQUIRY TERMS OF REFERENCE

- 1.1 On 7 August 2013 the Standing Committee on Environment and Public Affairs (**Committee**) resolved to commence an inquiry of its own motion into the implications for Western Australia of hydraulic fracturing for unconventional gas.¹
- 1.2 The Committee has observed that this is an issue marked by fierce controversy, in the face of which there has been a lack of non-partisan information available to the public. The purpose of this inquiry has been to produce a factual and dispassionate report to assist current and future decision-makers and the community in their consideration of the subject.
- 1.3 The terms of reference for this inquiry are as follows:

To inquire into and report on the implications for Western Australia of hydraulic fracturing for unconventional gas, including:

- a) how hydraulic fracturing may impact on current and future uses of land;*
- b) the regulation of chemicals used in the hydraulic fracturing process;*
- c) the use of ground water in the hydraulic fracturing process and the potential for recycling of produced water; and*
- d) the reclamation (rehabilitation) of land that has been hydraulically fractured.*

COMMITTEE PROCEDURE

- 1.4 The Committee called for public submissions by issuing an electronic Media Release on 14 August 2013 and placing an advertisement in *The West Australian* newspaper on Saturday 17 August 2013. The Committee acknowledges the huge public interest in this inquiry and the ongoing coverage by the international media of hydraulic fracturing and the onshore gas industry.

¹ On 13 August 2013, the Committee tabled a report in the Legislative Council containing the terms of reference for its inquiry as required under Standing Order 179(2).

- 1.5 At the end of the formal period for submissions, the Committee had received 114 public submissions from various community organisations, government departments, industry bodies and companies and private individuals. Due to the overwhelming public interest and significance of this inquiry, the Committee continued to accept additional submissions, as required, from stakeholders as the inquiry progressed.
- 1.6 In total, the Committee received 116 public submissions. Submissions received are noted in **Appendix 1**.
- 1.7 The Committee notes that several public submissions expressed disappointment that the terms of reference for this inquiry were too narrow in scope or did not include important issues, such as air quality issues related to hydraulic fracturing. Some public submissions raised concerns about the potential cumulative impact of hydraulic fracturing on land and the social impact on communities.² The Wilderness Society (WA) Inc. submitted that:
- in the Canning Basin, there would potentially be thousands of separate fracking operations; thousands of production wells; hundreds of kilometres of new roads and tracks; billions of litres of water use, and hundreds of miles of pipelines.*
- Nowhere has this been explained to affected communities, despite politicians talking up the huge potential of the industry in the region.*³
- 1.8 Prior to determining the inquiry's terms of reference, the Committee researched the topic of hydraulic fracturing broadly, using both Australian and international sources, before deciding to focus on the main areas of concern relevant to Western Australia. The Committee is satisfied that the four issues emphasised in its terms of reference: land impact, chemical use, water quality and the legacy of hydraulic fracturing reflect recurring concerns identified in submissions received.
- 1.9 The Committee has found its terms of reference to be sufficiently broad to accommodate the areas of concern raised by the community during the inquiry and no submissions were declined.
- 1.10 In September 2013 the Conservation Council of Western Australia conducted an online campaign titled 'Take Action: Gas Fracking Parliamentary Inquiry.' As a result of this online campaign, the Committee received in excess of 2200 pro forma emails, including multiple emails from identical email addresses. The Committee resolved not to include these emails as submissions due to the repetitive nature of the content, which added little to the Committee's understanding of the issues surrounding

² For example, Submission 24 from Erica Brock, 18 September 2013 and Submission 46 from Adriana Pracas, 19 September 2013.

³ Submission 7 from The Wilderness Society (WA) Inc., 5 September 2013, p 2.

hydraulic fracturing in this State. The Committee also notes that individuals who participated in the online petition had an opportunity to directly provide a personal submission to the Committee.

- 1.11 The public submissions received are available to view via the Committee website created for the inquiry at: <http://www.parliament.wa.gov.au/env/fracking>.
- 1.12 The Committee held several rounds of hearings over the course of its inquiry. Transcripts of public hearings are available from the Committee's website. A list of hearings conducted is at **Appendix 2**. Hearings were held at the Legislative Council Committee Office unless otherwise noted.
- 1.13 The Committee also conducted several site visits. These visits enabled face-to-face discussions with internationally-recognised experts in the various scientific fields related to hydraulic fracturing and the gathering of evidence from jurisdictions with broader experience in unconventional gas mining than our nascent onshore industry.
- 1.14 The Committee examined both operational and decommissioned well sites where hydraulic fracturing has occurred. This has given the Committee a unique insight into the current and potential future impact of unconventional gas mining on the Western Australian landscape. The Committee has learned that issues such as the protection of groundwater, chemical disclosure requirements and obtaining a social licence to operate are universal concerns when discussing hydraulic fracturing, which has enabled the Committee to benefit from lessons learned in other jurisdictions.
- 1.15 The Committee received briefings, organised site visits and tours of world-class research facilities in the United Kingdom (**UK**) and the United States of America (**USA**) and met with residents from affected communities. Members of the Committee had the opportunity to question world-renowned experts on induced seismicity, human health impacts, groundwater protection and learn from the experiences of other countries whose unconventional gas industries are more developed than our own.
- 1.16 A list of site visits and travel undertaken is attached at **Appendix 3**.
- 1.17 The Committee expresses its sincere thanks to all witnesses in this State, interstate and overseas who gave their valuable time and input to this inquiry and thanks all people involved in the organisation and facilitation of its site visits.

OTHER INQUIRIES AND NOTABLE REPORTS

- 1.18 When the Committee resolved to undertake this inquiry in 2013, it was the first Australian parliamentary committee to inquire into hydraulic fracturing for shale gas in Australia. This two year inquiry has involved extensive community engagement

through public hearings, site visits and detailed analysis of current research available on hydraulic fracturing.

- 1.19 The Committee is aware of several other inquiries into hydraulic fracturing which are either currently underway or recently finalised, both nationally and overseas, some of which may have been motivated, in part, by this inquiry. These reports and research have helped the Committee to focus its inquiry on the specific issues that relate to onshore shale gas and hydraulic fracturing in Western Australia.
- 1.20 A summary of Australian and international reports considered by the Committee is at **Appendix 4**.
- 1.21 The Committee acknowledges that the issue of hydraulic fracturing and its implications for the environment is a live issue globally, with ever-increasing community interest and engagement. The science and innovation of fracture stimulation for unconventional gas is constantly evolving and being refined as scientific experts (both proponents and opponents of the industry) examine data and publish peer-reviewed reports to reflect advances in technology.

STRUCTURE OF THIS REPORT

- 1.22 Chapter 3 explains the process of hydraulic fracturing and discusses the differences between shale gas and coal seam gas and the geology of Western Australia's landscape which has resulted in onshore gas being abundant in our State.
- 1.23 Chapter 4 discusses the legislative framework surrounding onshore gas extraction and the agencies involved in the regulation of hydraulic fracturing in Western Australia. This chapter also discusses how hydraulic fracturing is regulated internationally and in other Australian States and Territories.
- 1.24 Chapters 5 to 8 discuss the highlighted terms of reference for this inquiry. These chapters deal individually with the concerns raised by the community in relation to these matters, taking into account scientific data and evidence that the Committee received during this inquiry.
- 1.25 Chapter 9 discusses other recurring themes identified during the inquiry: induced seismicity, possible impacts on air quality and human health.
- 1.26 Chapter 10 discusses the concept of industry's social licence to operate and the importance of community acceptance if unconventional gas extraction is to develop in this State. The Committee believes that a robust debate on hydraulic fracturing must address the concept of the social licence.
- 1.27 Chapter 11 contains the Committee's conclusions.

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- 1.28 The Committee is confident that this report presents a comprehensive and unbiased examination of the main issues that surround hydraulic fracturing in Western Australia.

CHAPTER 2

BACKGROUND TO THE INQUIRY

The US fracking boom is several years old now, and so far little shale gas or tight oil production is occurring in other parts of the world. This could simply be a problem of timing: perhaps the rest of the world will eventually catch up with North America. On the other hand, there could be fundamental barriers to the widespread application of fracking technology outside the United States.

R Heinberg,

*Snake Oil: How Fracking's False Promise of Plenty Imperils Our Future*⁴

- 2.1 Energy security is increasingly a priority for governments, whether due to supply concerns or increased potential for domestic production. The global demand for natural gas has therefore meant that new technologies to extract the resource have emerged and unconventional gas is now firmly in the spotlight.
- 2.2 Over the past decade, advances in unconventional gas mining (through hydraulic fracturing and horizontal drilling) led to a surge in gas production in the USA and increased focus on shale gas as an alternative to traditional conventional gas resources. Innovations such as the use of proppants and new additives (see CHAPTER 3) resulted in the USA enjoying a new kind of energy security and becoming almost self-sufficient in gas.
- 2.3 In a short space of time, the USA has gone from expectations of increasing its net natural gas imports to being a world leader in global unconventional gas output: in 2010, 76 per cent of the world's unconventional gas came from the USA.⁵ The unique situation in the USA has also been a result of economic and societal factors, including the number of entrepreneurial and independent companies willing to venture into a new industry and a well-developed financial market.⁶
- 2.4 The rapid development of the shale gas industry has been variously described as a 'revolution',⁷ a 'paradigm shift',⁸ a 'boom'⁹ and a 'golden age'.¹⁰ Shale gas has also

⁴ R Heinberg, *Snake Oil: How Fracking's False Promise of Plenty Imperils Our Future*, Post Carbon Institute, Santa Rosa, 2013, p 73.

⁵ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 64.

⁶ *Ibid*, p 67.

⁷ D Brooks, New York Times, *Shale Gas Revolution*, 3 November 2011. Available at: <http://www.nytimes.com/2011/11/04/opinion/brooks-the-shale-gas-revolution.html>. Viewed 20 January 2015.

been called a ‘game changer’ by commentators and industry.¹¹ These words, however, have been used to describe the push towards natural gas as an energy source in the USA and may not be as relevant to our situation in Western Australia as originally predicted.

- 2.5 The USA’s ‘golden age’ of unconventional gas has also galvanised community concerns about fossil fuels generally into the issue of hydraulic fracturing and its potential risks to the environment.
- 2.6 The future of energy use and increasing dependence upon the fossil fuel industry means that many countries may need to explore alternative sources of energy to meet demand. Whether this be in the form of unconventional fossil fuels, sustainable energy sources or, more likely, a combination of both, the Committee is of the view that there is a need for informed debate and further scientific study to better inform governments of the day and the public of these matters.

CONTROVERSY SURROUNDING HYDRAULIC FRACTURING

- 2.7 The community has been polarised by the issue of whether resource companies should be allowed to use hydraulic fracturing on wells if there is a risk of damage (however small) to the environment, property or humans.
- 2.8 Proponents of hydraulic fracturing argue that all energy production has a level of risk and that the dangers of hydraulic fracturing are exaggerated; opponents refer to the ‘precautionary principle’¹² that should be applied to all decisions concerning the environment and human health and that, if there is any risk, then hydraulic fracturing should not be permitted. The Committee is of the view that debate on hydraulic fracturing has become over-simplified and clouded by irrelevant issues, further fuelling the controversy, rather than dispelling confusion.
- 2.9 In the Committee’s view, the answer to the question of whether it is appropriate to permit hydraulic fracturing or not lies somewhere between these two views. The

⁸ 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**).

⁹ 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-press-office/2013/02/12/remarks-president-state-union-address>. Viewed 21 January 2015.

¹⁰ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012.

¹¹ See for example, AM Jaffe, ‘Shale Gas Will Rock the World’, *Wall Street Journal*, 10 May 2010 and US Energy Information Administration, *Review of Emerging Resources: US Shale Gas and Shale Oil Plays: Analysis and Projections*, 8 July 2011. Available at: <http://www.eia.gov/analysis/studies/usshalegas/>. Viewed 21 January 2015.

¹² For further information on the Committee’s Terms of Reference, see Report 9, *Annual Report 2006*, 8 May 2007, Chapter 6.

purpose of this inquiry was to investigate the issues, free from bias and emotion. A multi-party Legislative Council standing committee is one of the few vehicles capable of being used for such a purpose.

- 2.10 All petroleum extraction activity contains elements of risk. What is important is how much weight is placed on the question of relative risk versus the reward obtained. There are members of the community who will always object to the mining industry, just as other people will always make light of the risks for the sake of progress and profit.
- 2.11 In the Committee's view, governments need to ensure that policy-making acknowledges the inherent risk in energy production and, if a decision is made to proceed with exploration and development, that there are cogent reasons for the decision that the community can understand. This will ensure that any policy decision to permit or ban wide-scale hydraulic fracturing is able to withstand robust scrutiny from all sides of the debate.
- 2.12 During this inquiry, it has become apparent to the Committee that the terminology of hydraulic fracturing has been used by different groups to elicit various reactions in audiences. The words themselves, 'hydraulic fracturing', are abbreviated in different ways, depending on the author: for example, use of the shorthand 'frack' or 'frak' often by opponents to the technology, or the spelling 'fracc' or 'hydrofraccing' by industry groups.
- 2.13 Different words can be used to manipulate the facts of hydraulic fracturing and provoke an emotional response from people who may not be fully aware of the science behind claims made in the media or by interest groups. The Committee is of the view that emotion is a powerful argument in the debate on this topic, but not always a helpful one when sustaining logical discussion.
- 2.14 The Committee has used the full scientific phrase 'hydraulic fracturing' throughout this report, rather than the colloquial abbreviations 'fracking' or 'fraccing', as both terms can add unintended connotations to discussion of this topic.
- 2.15 In the Committee's view, there is a misconception amongst some parts of the community that all risks associated with mining can also be attributed to hydraulic fracturing. Adding the hydraulic fracturing process to the development of unconventional gas adds a layer of complexity and expense, but the risks associated with hydraulic fracturing (such as spills, leaks and well blowouts) are not unique to unconventional gas exploration.

- 2.16 The nature and timing of the controversy surrounding hydraulic fracturing was a motivation behind the Committee's resolution to commence this inquiry.
- 2.17 In light of the increased focus on an onshore gas industry in Western Australia, the Committee considered it timely to investigate the claims made by both proponents and opponents of hydraulic fracturing.

CHAPTER 3

SHALE GAS, COAL SEAM GAS AND HYDRAULIC FRACTURING

Whilst shale gas has enormous potential, it will require great skill, persistence, capital and careful management of any impacts on ecosystems and related natural resources, to realise that potential. It will also need 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.

Australian Council of Learned Academies¹³

- 3.1 Hydraulic fracturing is not a new process, but the controversy surrounding its use to extract unconventional gas is relatively recent. The technology behind hydraulic fracturing may be evolving and improving into the future, but the scientific and geological fundamentals are well-established.

UNCONVENTIONAL GAS

- 3.2 ‘Unconventional gas’ and ‘conventional gas’ are both terms used to refer to natural gas. Natural gas is formed by the breakdown of organic matter and is a combustible mixture of hydrocarbon gases (mainly methane: CH₄) and other gases such as carbon dioxide.¹⁴ It is a fossil fuel and a finite resource, as are petroleum and coal. Natural gas that is found in impermeable rock formations (which cannot readily form conventional gas deposits) is called unconventional gas. Types of unconventional gas include shale gas, coal seam gas and tight gas.
- 3.3 The difference between conventional gas and unconventional gas is therefore not one of chemical composition, but rather location. Conventional resources of gas are mostly found in sedimentary basins, in porous and permeable reservoir rocks such as sandstone, and in geological formations which make extraction relatively straightforward.

¹³ ACOLA Report, p 19.

¹⁴ Geoscience Australia. Available at: <http://www.ga.gov.au/scientific-topics/energy/resources/petroleum-resources/gas>. Viewed 22 January 2015.

3.4 **Figure 1** and **Figure 2** illustrate the relative size and locations of shale gas deposits in Australia.

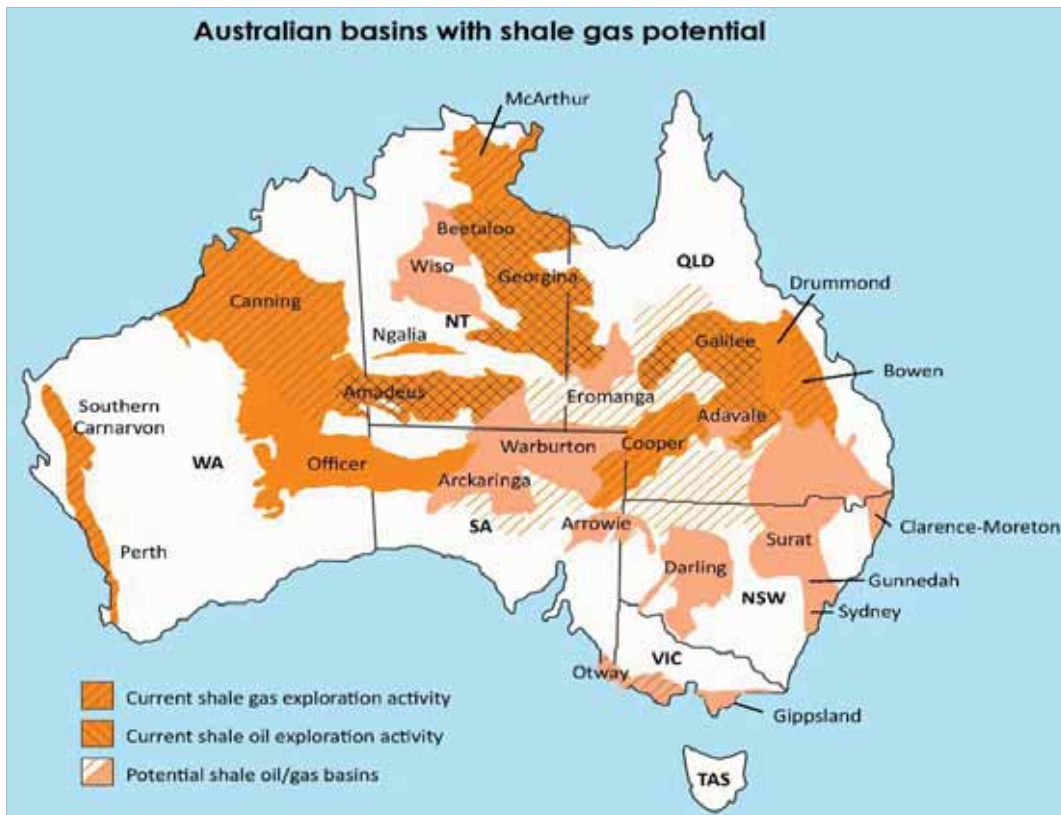
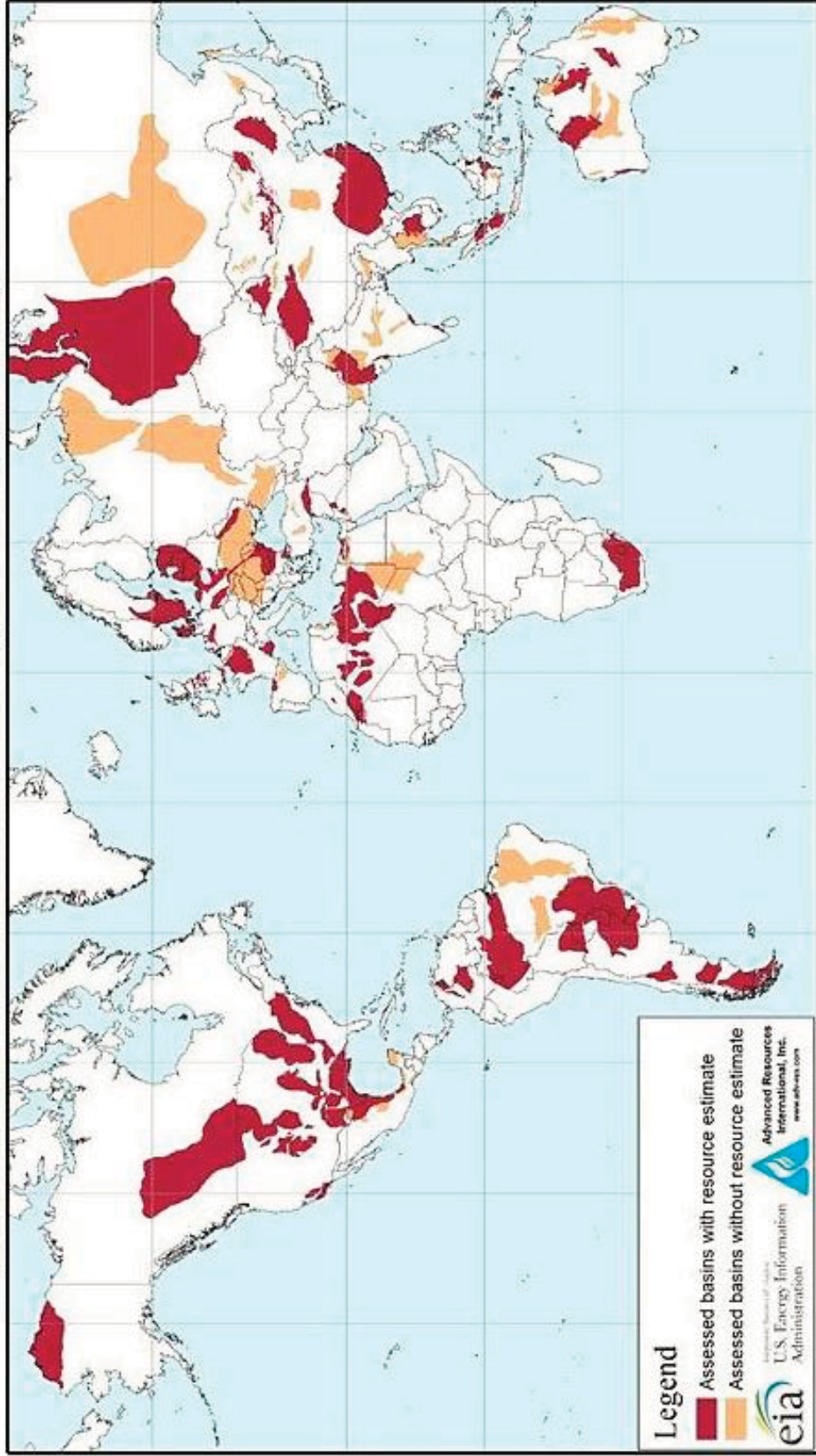


Figure 1. Australian basins with shale gas potential [Source: APPEA, *The Natural Gas Revolution: Natural Gas from Shale and Tight Rocks*]

Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies

Figure 2. Map of basins with associated shale oil and shale gas formations, as of May 2013 [Source: United States Energy Information Administration, June 2013]

3.5 Most of the gas produced globally and in Australia during the twentieth century has been conventional gas. The conventional gas and oil industries drive economic and social development in many countries. Western Australia has a long history of relying upon gas production, with Western Australia being the largest producer and consumer of natural gas in Australia: about 71 per cent of Western Australia’s petroleum production in 2012 was directly derived from the development of natural gas resources.¹⁵

3.6 Global demand for gas is predicted to increase by 57 per cent by 2040: the only fossil fuel forecast to still be growing significantly at that time.¹⁶ Unconventional gas, from shale especially, is predicted to become a much more widespread global phenomenon over the coming decades, with Australia becoming a world leader in production.¹⁷ The increasing pressure on conventional gas resources has led to a shift in focus to unconventional gas and its extraction.

3.7 Unconventional gas resources are found in formations that are not as easily accessible as conventional gas, both geologically and economically. **Figure 3** illustrates the differences in development cost and difficulty between conventional and unconventional gas.

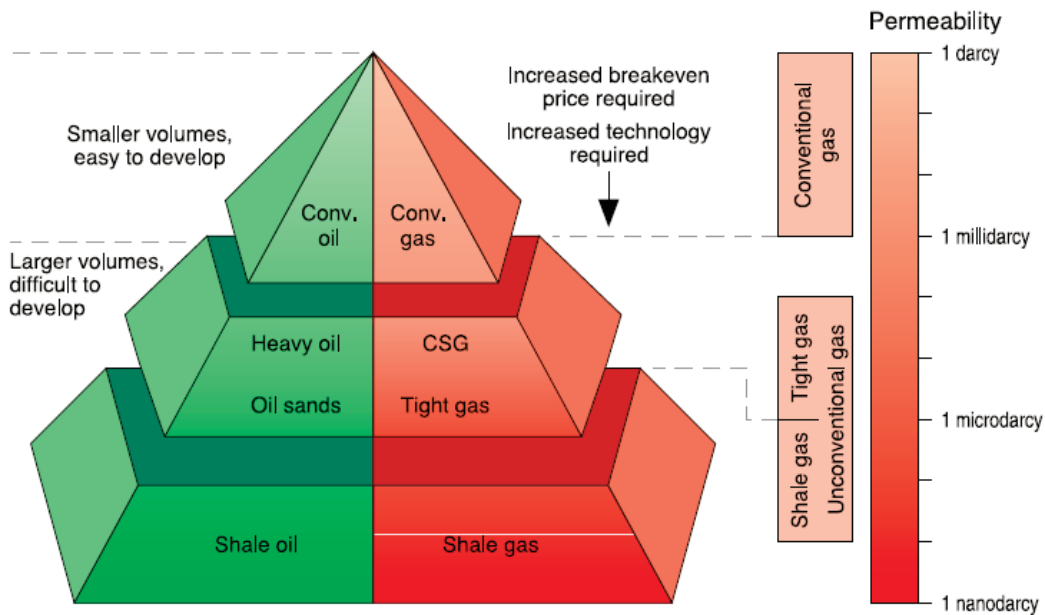


Figure 3. Petroleum resource pyramid, showing how resource quality varies with permeability [Source: Shaping a Nation: A Geology of Australia, Geoscience Australia]

¹⁵ Western Australia, Legislative Assembly, Economics and Industry Standing Committee, Report 2, *The economic impact of floating LNG on Western Australia: Volume 1*, 15 May 2014, p 2, quoting from Geoscience Australia, *Petroleum Reserves by basin, as at 1 January 2011*, May 2012.

¹⁶ International Energy Agency, *World Energy Outlook 2014*, 12 November 2014, p 146.

¹⁷ Ibid, p 147.

- 3.8 Unconventional gas includes shale gas, tight gas and coal seam gas (**CSG**) and requires a different method of extraction to conventional fuels. Whilst the umbrella term ‘unconventional’ applies to all of these types of gases, there are also differences between them, mainly in the properties of the host rock and the specific techniques for their extraction, such as the use of hydraulic fracturing and horizontal drilling.
- 3.9 Although the existence of unconventional gas resources has been recognised for decades, their full extent and importance has only recently been appreciated.¹⁸ As extraction technology has developed since the mid-20th century, unconventional gas has become more economic to extract and therefore more attractive as an energy source.

SHALE GAS

- 3.10 Shale gas is the term applied to natural gas which is trapped within shale rocks. Shale is a common type of fine grain sedimentary rock formed from deposits of mud, silt, clay and organic matter, usually occurring at depths more than 1500 metres below the Earth’s surface. Due to the low permeability and porosity of shale, gas cannot escape (or ‘migrate’) and is trapped in pockets within the rock.
- 3.11 The US Energy Information Administration estimates that there are 7299 trillion cubic feet (**tcf**) of technically recoverable shale gas resources in the world, distributed amongst 137 formations in 41 countries.¹⁹
- 3.12 Shale gas can often be found in dispersed, disconnected pockets throughout a shale formation, leading to a low rate of recovery (and therefore higher cost) compared to conventional gas. The area of gas of a shale basin where gas (or sometimes oil) can be commercially extracted is known as a ‘shale play’. Shale plays vary in thickness from a few metres to several hundred metres.
- 3.13 Shale resources are unevenly distributed across the world (see **Figure 2**) and their prospectivity can vary greatly according to local geology.

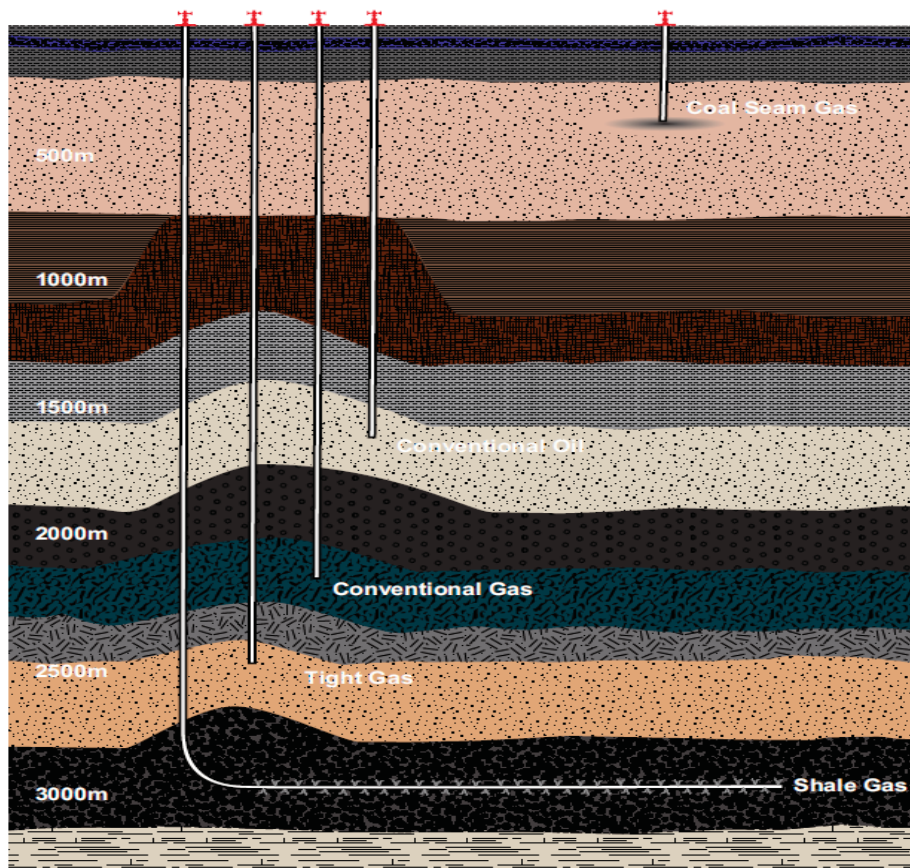
¹⁸ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 18.

¹⁹ United States 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. Available at: <http://www.eia.gov/analysis/studies/worldshalegas/>. Viewed 25 September 2014.

3.14 The top ten countries with technically recoverable shale gas resources are noted below:²⁰

Rank	Country	Shale gas (tcf)
1	China	1115
2	Argentina	802
3	Algeria	707
4	US	665
5	Canada	573
6	Mexico	545
7	Australia	437
8	South Africa	390
9	Russia	285
10	Brazil	245
World Total		7299

3.15 The following diagram illustrates typical oil and gas target depths in Western Australia (CSG gas depth in the diagram is indicative of eastern states geology as CSG is not prospective in Western Australia).²¹



²⁰ United States Energy Information Administration, June 2013.

²¹ Department of Mines and Petroleum, February 2014.

- 3.16 The depths at which shale gas is found can vary between 1500 metres to over 3000 metres under the ground, but certainly at depths greater than conventional sources. In contrast to conventional gas and oil reserves, shale gas almost always requires wells to drill horizontally through a formation, due to the unique geology of shale gas depths. The science and possible environmental impacts of horizontal drilling is discussed in more detail in Chapters 6, 7 and 9 of this report.

Where shale gas is found in Western Australia

- 3.17 Western Australia has a long history of producing gas and oil, mostly from offshore sources such as the North West Shelf. The Department of Mines and Petroleum (**DMP**) estimates that Western Australia's shale basins hold approximately 80 per cent of Australia's discovered natural gas resources, despite being one of the least explored areas in the world.²² The discovery of commercial quantities of natural gas onshore near Dongara in 1966 and subsequent development of the Perth Basin through the 1970s and 1980s foreshadowed that Western Australia also had onshore deposits worthy of further exploration.
- 3.18 Prospective resources of shale gas in Western Australia are clustered below three broad areas in the State: the Kimberley, East Pilbara and Midwest (see **Figure 4**). The two main shale gas deposits which have potential for future development are the Canning and Perth Basins. Other potential resources include the Carnarvon and Officer Basins, which are currently untested for prospectivity or production.

²² Department of Mines and Petroleum, *Western Australia's Petroleum and Geothermal Explorer's Guide: 2014 Edition*, September 2014, p 18.

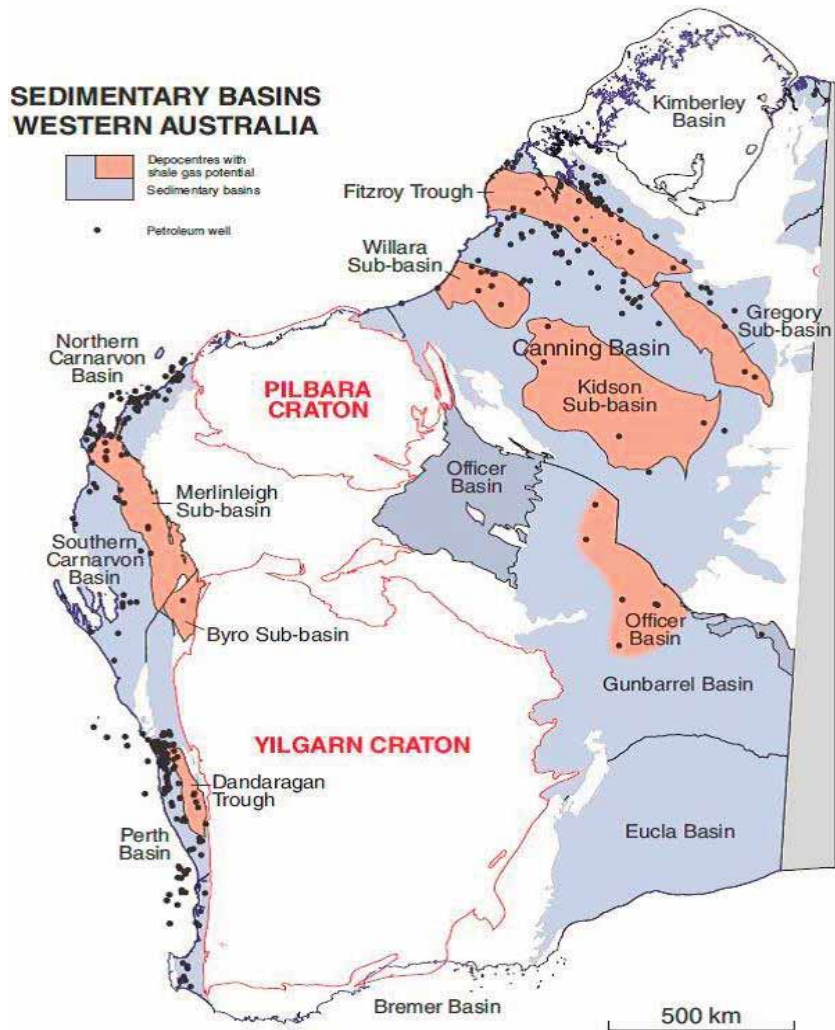


Figure 4. Sedimentary basins in Western Australia (in blue) showing depocentres with shale gas potential [Source: Department of Mines and Petroleum]

3.19 DMP estimates that the size of the deposits in Western Australia ranges from 268 to 280 tcf.²³ These figures vary significantly from the figure of 11 tcf quoted by the International Energy Agency (IEA) (see paragraph 3.33), which demonstrates that the nature and extent of our State’s shale gas resources is still uncertain. The Committee has focused on the Canning and Perth Basins in this report as these two formations appear to be the most prospective for onshore shale gas in Western Australia.

Canning Basin

3.20 The Canning Basin in the Kimberley region of Western Australia is sometimes referred to as a ‘superbasin’ and contains several ‘sub-basins’ (see **Figure 4**). It covers a total area of more than 640 000 square kilometres, with 530 000 square kilometres

²³ Data taken from Submission 105 from Department of Mines and Petroleum, 3 October 2013, p 8 and *Natural Gas from Shale and Tight Rocks: An overview of Western Australia’s regulatory framework*, February 2014, p 4. Available at: <http://www.dmp.wa.gov.au/shaleandtightgas/>.

occurring onshore and the remainder extending offshore. The US Energy Information Administration estimated in 2013 that the Canning Basin holds more than 225 tcf of recoverable shale gas.²⁴ Two urban centres provide shipping and air support for the Canning Basin: Broome and Derby, while major roads service only parts of the basin, particularly near the coast. Much of the central and southern areas of the Canning Basin are remote and unsettled, with a poorly maintained regional network of tracks as the only access points.²⁵

- 3.21 As of November 2013, nearly 300 onshore petroleum wells had been drilled in the Canning Basin.²⁶ The Committee notes that any exploitation of onshore shale gas resources in the Canning Basin will face unique challenges, including the lack of established infrastructure in remote parts of the Kimberley and the impact of the region's wet season on mining operations and costs. The Committee visited Broome in 2014 and notes that there are also ongoing issues related to a social licence to operate and community support for hydraulic fracturing (see CHAPTER 10).

Perth Basin

- 3.22 Covering an area of about 100 000 square kilometres (45 000 square kilometres is onshore), the Perth Basin lies under land that is well-established as an agriculture and forestry region, with main roads that provide easy access.²⁷ Whilst smaller in area, the region has seen more gas exploration and development than the Canning Basin, commencing in the mid-1960s.
- 3.23 Several onshore gas wells in the Perth Basin have been subject to hydraulic fracturing since the mid-2000s, mainly in the Dongara gas field. In 2010, Woodada Deep 1 was the first well drilled for shale gas targets in the Perth Basin.²⁸ The Committee has visited several sites in the area, including the Drover-01 and Arrowsmith-02 wells, and has spoken to the community and exploration companies active in the area. One of the main concerns expressed by residents is the protection of the Mount Peron Water Reserve in the Shire of Coorow (see CHAPTER 7).

²⁴ United States 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. Available at: <http://www.eia.gov/analysis/studies/worldshalegas/>. Viewed 25 September 2014.

²⁵ Department of Mines and Petroleum, *Summary of Petroleum Prospectivity: Canning Basin*, February 2014, p 19.

²⁶ Ibid, p 9.

²⁷ Department of Mines and Petroleum, *Summary of Petroleum Prospectivity: Perth Basin*, February 2014, p 3.

²⁸ Ibid, p 14.

3.24 There are environmentally sensitive areas present in the region and native title and land access negotiations are key issues in this region.²⁹ The Committee notes that the trend of onshore gas development in the Perth Basin looks set to continue, as recent discoveries of commercially viable shale gas deposits have been lauded as the largest onshore gas fields ‘found in Western Australia for decades.’³⁰

COAL SEAM GAS

3.25 Most of the current debate in Australia around hydraulic fracturing is related to the CSG industry in the eastern states, so it is essential to understand the difference between shale gas and CSG. Whilst the process of hydraulic fracturing is the same, differences in geology between shale gas and CSG result in different levels of risk and water and chemicals use.

3.26 CSG is natural gas which has been entirely adsorbed into the coal matrix, typically at relatively shallow depths of between 300 to 1000 metres (see **Figure 5**). CSG is held underground within coal through pressure from formation water in the coal fractures.³¹ CSG is therefore extracted by ‘dewatering’, which reduces the water pressure within the coal matrix and releases the gas from the coal. The Australian CSG industry is based in Queensland and New South Wales. There are no known prospective CSG resources in Western Australia.

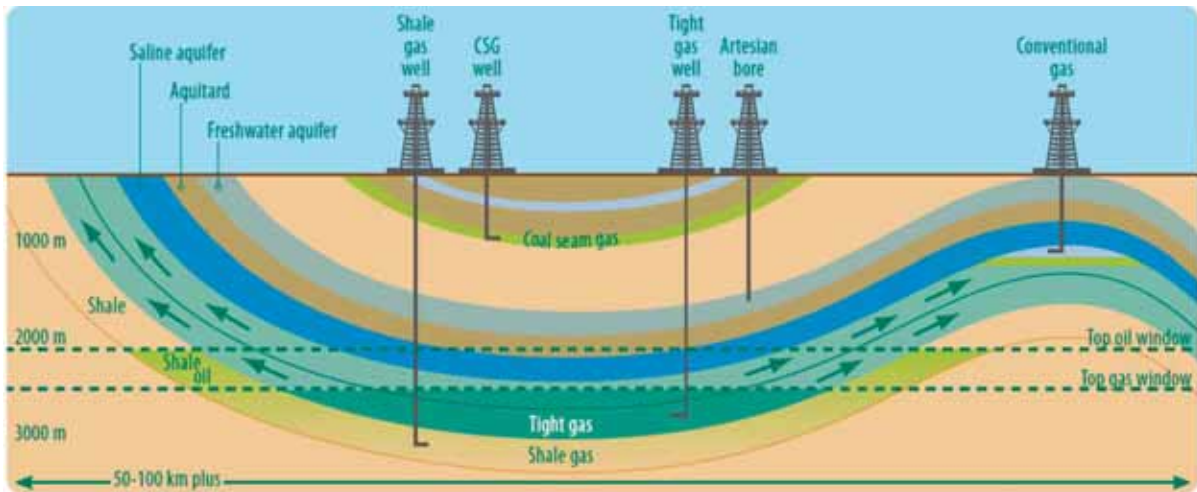


Figure 5. Geological settings for unconventional gas [Source: ACOLA Report, courtesy of US Energy Information Administration, 2010]

3.27 The main differences between CSG mining and shale gas mining are:

²⁹ Department of Mines and Petroleum, *Summary of Petroleum Prospectivity: Perth Basin*, February 2014, p 22.

³⁰ K Diss, ‘WA’s largest gas field find in decades commercially viable, explorer AWE says’, *ABC News Online*, 10 March 2015.

³¹ CSIRO Factsheet, ‘What is coal seam gas?’, September 2013.

- CSG extraction produces water; shale gas extraction requires water.
- CSG is found at shallow depths; shale gas is deep underground.
- CSG can be extracted without using hydraulic fracturing; shale gas almost always requires hydraulic fracturing to access deposits.³²

3.28 The Australian Council of Learned Academies (**ACOLA**) focused on shale gas in its analysis of unconventional gas production in Australia as the CSG industry is well-established in this country and also because:

*there are many lessons, some negative, some positive, to be learned from the technical experience of the CSG industry.*³³

GOLDEN RULES FOR A GOLDEN AGE OF GAS

3.29 In 2012, IEA developed a set of ‘Golden Rules for a Golden Age of Gas’ (**Golden Rules**) for its outlook for global unconventional gas production. The IEA noted that, as unconventional gas resources are increasingly exploited for our energy needs in the future:

*society needs to be adequately convinced that the environmental and social risks will be well enough managed to warrant consent to unconventional gas production, in the interests of the broader economic, social and environmental benefits that the development of unconventional resources can bring.*³⁴

3.30 The Golden Rules allow policy-makers, regulators, operators and other stakeholders to address the environmental and social impacts of unconventional gas mining in order to earn and retain that consent.³⁵ The Golden Rules are:

1. *Measure, disclose and engage*
2. *Watch where you drill*
3. *Isolate wells and prevent leaks*
4. *Treat water responsibly*
5. *Eliminate venting, minimise flaring and other emissions*
6. *Be ready to think big*
7. *Ensure a consistently high level of environmental performance.*³⁶

³² CSIRO Factsheets, ‘What is coal seam gas?’, September 2013; ‘Coal seam gas developments – predicting impacts’, August 2014; ‘Coal seam gas – produced water and site management,’ August 2014.

³³ ACOLA Report, 2013, p 34.

³⁴ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 42.

³⁵ The Committee will discuss the concept of social consent, also known as a ‘social licence to operate’ in CHAPTER 10 of this report.

- 3.31 As the authors of the phrase ‘a golden age of gas’, IEA developed the Golden Rules to guide government and industry into the future. The Golden Rules represent the ideal outcome where continual global expansion of gas supply from unconventional resources is achieved.³⁷
- 3.32 The IEA also considered the opposite turn of events in its prediction of a future up to the year 2035, where environmental and other constraints prove too difficult to overcome and the Golden Rules are not adopted. This ‘Low Unconventional Case’ discusses the situation where the potential social and environmental threats posed by an unconventional gas industry are deemed too significant in a particular country and the development of that industry stalls.³⁸
- 3.33 IEA’s projections for Australia focused mostly on CSG, as the CSG industry is currently far more developed than shale gas production in Australia. The IEA did, however, observe that Australia’s remaining recoverable shale gas deposits were estimated (at the time of the report) to be 11 tcf, with a ‘boom in shale gas production’ unlikely in the near future because of logistical and economic difficulties.³⁹ The vast majority of production is derived from CSG resources on the east coast of Australia. In IEA’s Low Unconventional Case for Australia, however, only 40 per cent of CSG resources is assumed to be exploited and there is no mention of shale gas exploitation in Western Australia at all.⁴⁰
- 3.34 In the Committee’s view, if shale gas resources are to be exploited and developed to the best of their potential with minimum impact on the environment, then the principles in IEA’s Golden Rules must be relied upon and considered when developing a regulatory framework and pursuing what is known as a ‘social licence’ to operate (see CHAPTER 10). The Golden Rules note that:

[the] prospects for unconventional gas production in Australia hinge to a large degree on whether policy-makers and the industry itself can sustainably manage the associated environmental risks on a basis that retains public confidence in the outcomes.⁴¹

³⁶ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, pp 13-14 and International Energy Agency, *Golden Rules for a Golden Age of Gas: May 29, London, Presentation to Media*, p 2.

³⁷ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 64.

³⁸ Ibid, p 66.

³⁹ Ibid, p 132.

⁴⁰ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 71.

⁴¹ Ibid, p 134.

3.35 The Committee notes that, since the publication of the Golden Rules in 2012, the IEA has reconsidered Australia's role in the global development of unconventional gas, with Australia set to 'pick up the baton' over the coming decades, along with other nations.⁴² The Committee's view is that if Australia is to become such a key player in the global unconventional gas industry then robust and open discussion of hydraulic fracturing for unconventional gas is essential. This report aims to contribute meaningfully to such a discussion.

HYDRAULIC FRACTURING

3.36 The first experimental use of fracturing to stimulate a mine occurred in 1947 at the Hugoton gas field in Grant County, Kansas, USA.⁴³ This first (largely unsuccessful) attempt used 1000 gallons of petrol thickened with napalm and sand to stimulate a limestone formation 2400 feet deep.⁴⁴ It was not until two years later, when Halliburton Oil Well Cementing Company in Texas (now Halliburton) was granted an exclusive licence to use the new process, that hydraulic fracturing on a commercial scale began in the USA.⁴⁵

3.37 The basic concept of forcing fluid at high pressure into gas (or oil) producing geological formations to stimulate flow has not changed drastically since the 1950s. What has changed is the type of fluid used, the amount of pressure applied and advances related to how the well is drilled (including horizontal drilling and multi-well pads). Hydraulic fracturing has been described as requiring a 'combination of brute force and sophisticated technology.'⁴⁶

3.38 According to the IEA, the cost of multi-stage hydraulic fracturing in the USA can add between US\$1 million and US\$4 million to the construction costs of a well, depending on its location, depth and other drilling factors.⁴⁷

3.39 DMP has advised that, in Western Australia, the cost of setting up a drilling rig and related infrastructure for onshore unconventional gas development can range from 'as cheap as \$2 million' to as much as \$15 or \$20 million if 'something goes wrong in a

⁴² This includes China, India and Argentina: International Energy Agency, *World Energy Outlook 2014*, 12 November 2014, p 147.

⁴³ CT Montgomery & MB Smith, 'Hydraulic Fracturing: History of an enduring technology', *Journal of Petroleum Technology*, December 2010, p 27.

⁴⁴ One thousand gallons is equivalent to 3785 litres and 2400 feet is about 730 metres.

⁴⁵ A Prud'Homme, *Hydrofracking: What everyone needs to know*, Oxford University Press, New York, 2014, p 27.

⁴⁶ 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, p 4.

⁴⁷ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 53.

more remote spot.⁴⁸ Adding hydraulic fracturing to the drilling process can increase costs in the range of several million dollars for every individual hydraulic fracture that is planned (each well typically requires several fracture treatments: see paragraph 6.15).

The process

3.40 The process involves pumping a hydraulic fracturing fluid mixture (usually water, proppant and chemicals) at controlled high pressure into an underground gas reservoir to induce fractures in the rock (see **Figure 6**). A perforating gun will ‘shoot holes’ through the casing and a short way into the shale rock, then the fracturing fluid is injected at high pressure to crack the rock and release any gas present.⁴⁹ The proppant is used to hold open the resulting fractures so that gas can escape from the formation and flow to the surface through the well’s production casing.⁵⁰

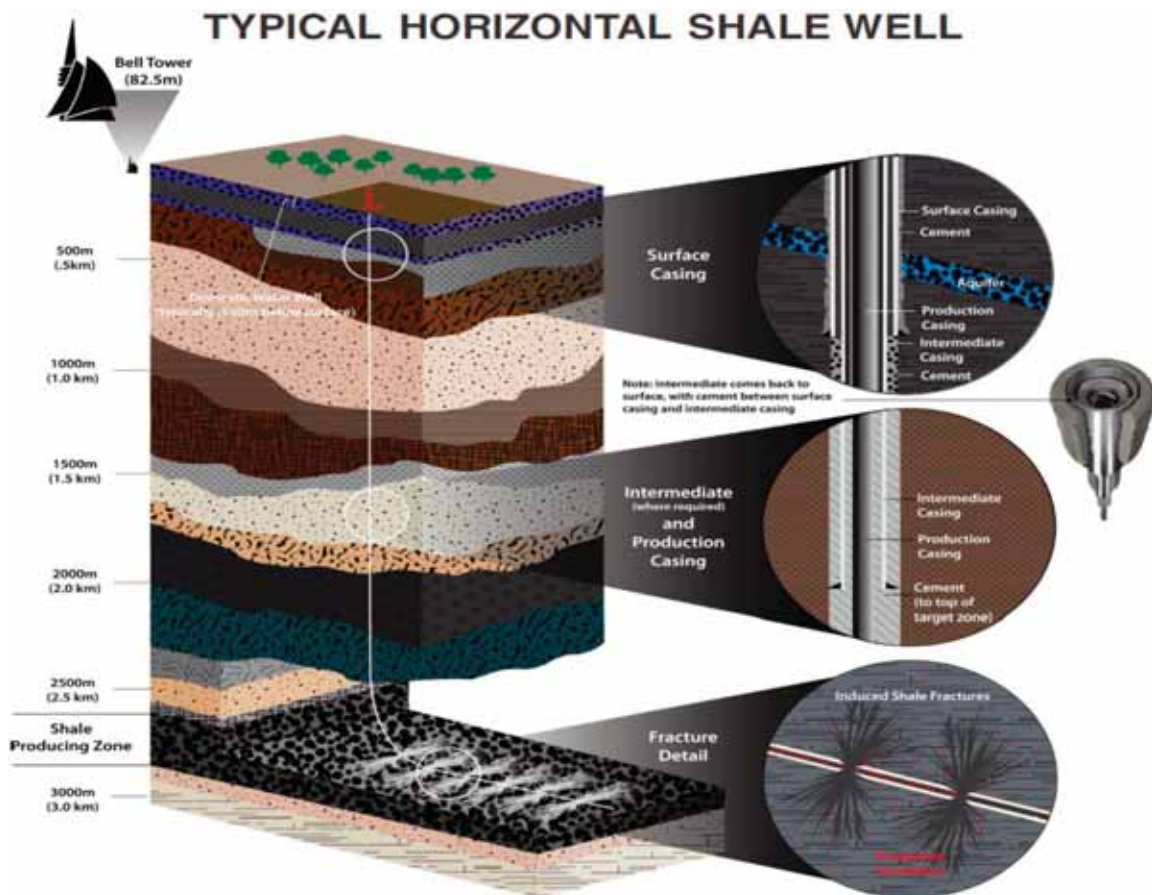


Figure 6. Diagram showing typical horizontal shale well with hydraulic fracturing detail [Source: Department of Mines and Petroleum, August 2013]

⁴⁸ Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 13.

⁴⁹ New Zealand, Parliamentary Commissioner for the Environment, *Evaluating the environmental impacts of fracking in New Zealand: An interim report*, November 2012, p 38.

⁵⁰ ACOLA Report, pp 57-58.

- 3.41 The process of well drilling and completion typically takes several weeks, involving stages of drilling, insertion of steel casing strings, cementing, testing and then establishing a connection to the shale reservoir itself, which is then hydraulically fractured. At each stage of drilling, a jointed steel casing is inserted, then cement is pushed down the casing inner diameter to its end, forcing the cement back up the annulus between the casing outer diameter and the drilled rocks, and between the sleeved casings themselves, where they overlap.⁵¹
- 3.42 Large amounts of fluid (flowback) is returned to the surface with any gas that is produced. Flowback consists of the fracturing fluid initially injected into the formation; between 15 and 50 per cent of the fluid can be recovered from a well.⁵²
- 3.43 DMP advised that, since 2005, 15 wells in Western Australia have been explored for shale and tight gas. Seven of these wells were fractured, with six of the seven occurring in the last five years.⁵³ The department also submitted that ‘approximately 740 hydraulic fracture stimulations [for oil] have occurred on Barrow Island in nearly 50 years, an island 202 square kilometres in area.’⁵⁴ **Figure 7** illustrates historic data for hydraulic fracturing that has occurred in Western Australia.

FIELD	LOCATION	YEAR
Gingin Field	Gingin	1971
Whicher Range	Mid West	1982 (WR-3), 1997 (WR-1 & WR-4), 2003 (WR-5)
Warro	Mid West	2009 (W-3), 2011 (W-4)
Yulleroo	Canning Basin	2011
Arrowsmith	Mid West	2012
Senecio	Mid West	2012
Woodada	Mid West	2012

Figure 7. Historic hydraulic fracturing for tight and shale gas in WA [Source: Submission 104, APPEA, 2013]

Technology

- 3.44 During this inquiry, the Committee has become aware of new technology which is being used internationally to reduce the environmental impact and risk of hydraulic fracturing. Techniques such as horizontal drilling and the use of multi-well pads have been extensively developed in the USA to reduce costs. Horizontal drilling allows for more wells to be drilled closer together at the surface that then diverge at depth.

⁵¹ ACOLA Report, p 55.

⁵² Ibid, pp 57-58.

⁵³ Submission 105 from Department of Mines and Petroleum, 3 October 2013, p 8.

⁵⁴ Ibid, p 5.

3.45 DMP advised the Committee that, should shale gas development proceed in Western Australia, multiple horizontal wells on a single site could be used to complete wells.⁵⁵

Figure 8 illustrates the typical area needed for a multi-well pad in British Columbia.



Figure 8. The area needed for a multi-well pad. This well pad in north eastern British Columbia has a total of 18 to 20 operational shale gas wells [Source: Council of Canadian Academies, courtesy Nexen Energy ULC]

3.46 In the USA, a typical shale gas well site averages between 1.5 and 2.0 hectares in size during drilling, but pads of over 2.0 hectares are possible.⁵⁶

3.47 The size of the well pad is determined by the space required to accommodate equipment for hydraulic fracturing, horizontal drilling and space for fluid storage. The ACOLA Report highlighted that the footprint of shale gas operations can be minimised through measures such as the use of multi-well pads being drilled on a single area. **Figure 9** illustrates the typical layout and size (160 square metres) of a well site during hydraulic fracturing operations.

Finding 1: The Committee finds that when horizontal drilling and multi-well pad technology are used during hydraulic fracturing for unconventional gas, the surface footprint of the process is decreased, therefore also minimising the environmental impact of hydraulic fracturing.

⁵⁵ Ibid, p 10.

⁵⁶ ACOLA Report, p 103.

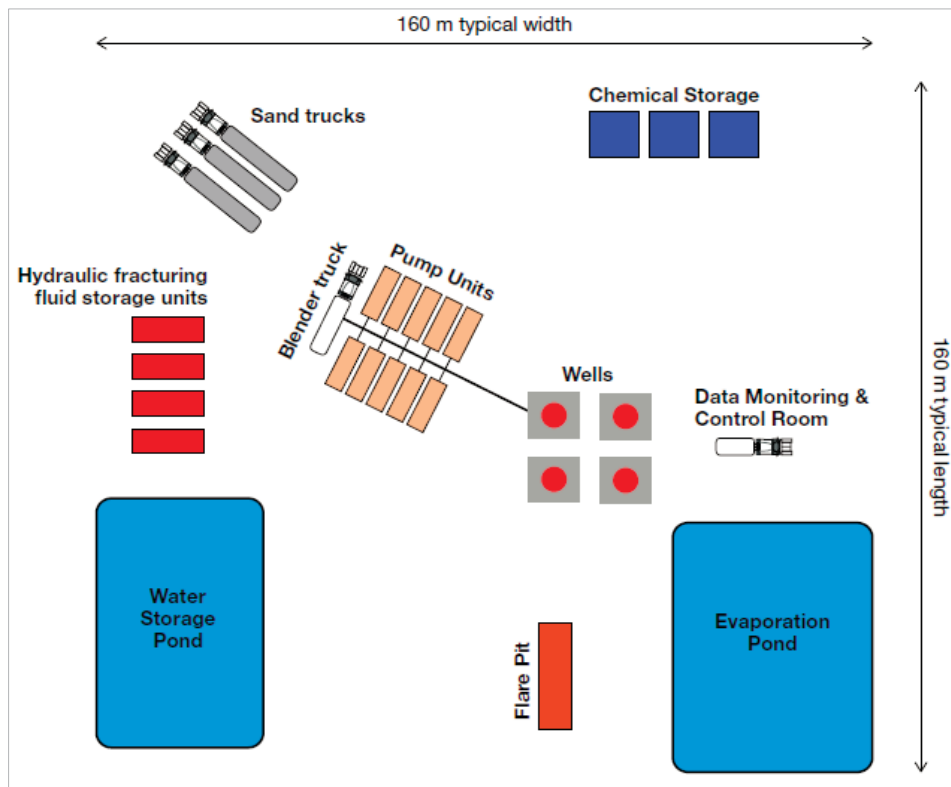


Figure 9. Schematic of the typical layout of a well site during hydraulic fracture stimulation [Source: Department of Mines and Petroleum, Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia, 2015]

CHAPTER 4

REGULATION OF HYDRAULIC FRACTURING

Proactively providing information on decisions, compliance and monitoring is also important for engendering trust. Much of the public concern over oil and gas extraction in New Zealand, and fracking in particular, appears to stem from a lack of trust in regulators that is fuelled by low levels of transparency.

Dr Jan Wright, New Zealand Parliamentary Commissioner for the Environment⁵⁷

4.1 This chapter addresses the following questions:

- What is the current regulatory framework governing hydraulic fracturing in Western Australia?
- How ready is existing legislation to deal with hydraulic fracturing exploration or production?
- Is the Executive prepared for an increase in the number of hydraulic fracturing permits?
- Are there lessons to be learned from the experience of regulators in other jurisdictions?
- Can the Western Australian community be confident this State has ‘best practice’ procedures in place for the unconventional gas industry?

MINING AND PETROLEUM LEGISLATION IN WESTERN AUSTRALIA

- 4.2 Western Australia has a long history of extractive industry, commencing from when minerals were first discovered in the State in 1842. The *Mining Act 1901* was originally enacted to regulate gold mining, however, the importance of gold mining gradually decreased during the first half of the last century.⁵⁸
- 4.3 It is important to note the interaction between State and Commonwealth legislation in mining law. The power to legislate for minerals located within State borders lies with the States, but the *Commonwealth Constitution* has relevance with regard to its powers

⁵⁷ New Zealand, Parliamentary Commissioner for the Environment, *Drilling for oil and gas in New Zealand: Environmental oversight and regulation*, June 2014, p 78.

⁵⁸ M Hunt, *Mining Law in Western Australia*, The Federation Press, Sydney, 2009, pp 3-5.

to make laws with respect to trade and commerce, taxation, corporations, native title and other constitutional matters which may affect the unconventional gas industry.⁵⁹

- 4.4 Western Australia has two main statutes that are relevant to the regulation of the onshore mining industry: the *Mining Act 1978* for mineral exploration and the *Petroleum and Geothermal Energy Resources Act 1967 (PGERA)* for petroleum and geothermal resources. The Mining Act expressly provides that it be ‘read and construed subject to the provisions of the *Environmental Protection Act 1986*’ and any clauses in the Mining Act will be inoperative to the extent that they are inconsistent.⁶⁰ There is no similar provision in the PGERA.
- 4.5 At common law it is presumed that the owner of the land also owns everything above or below that land, including minerals (which includes oil and gas), with the exception of ‘royal metals’ (gold and silver), the ownership of which was reserved for the Crown from as early as the sixteenth century. This ‘reservation’ of mineral ownership was extended to cover all minerals in Western Australia with the passage of the *Land Act 1898* (repealed).
- 4.6 However, since 1 January 1899 all new grants of freehold title in WA have included a provision reserving all minerals for the Crown. For titles granted before 1899, the owner of the land is also the owner of any minerals (other than gold or silver) below the land, unless the owner’s predecessor in title had transferred this ownership to someone else.⁶¹

The regulatory framework of hydraulic fracturing

- 4.7 The process for obtaining a licence to conduct petroleum activities (which can include exploration, drilling, hydraulic fracturing and commercial production) is very complex and involves many steps and permits granted by DMP under various statutes and instruments of subsidiary legislation. The PGERA (and associated regulations) is the main authority that regulates hydraulic fracturing.
- 4.8 There is no separate licensing regime under the PGERA for hydraulic fracturing; the process is largely regulated and licensed under existing legislation and approvals (but see paragraph 4.22).

⁵⁹ See section 51(i), (ii), (xx), (xxvi): ‘people of any race’, *Commonwealth Constitution*, M Hunt, *Mining Law in Western Australia*, The Federation Press, Sydney, 2009, pp 9-10.

⁶⁰ *Mining Act 1978* s 6(1).

⁶¹ M Hunt, *Mining Law in Western Australia*, The Federation Press, Sydney, 2009, pp 35-36.

Exploring for petroleum resources in Western Australia

- 4.9 DMP releases parcels of State land within Western Australia that are available for petroleum exploration biannually through its acreage release program.⁶² Details of the acreage releases are published in the Western Australian *Government Gazette*. DMP will assess the bids made and award a ‘Petroleum Exploration Permit’ (**PEP**) to the applicant who makes a successful bid for a particular acreage. The process for applying for a PEP is set out in section 31 of the PGERA. Section 39 of the PGERA provides that a PEP remains in force for six years initially, but can be renewed for a further five years on application.
- 4.10 If a PEP holder subsequently discovers a petroleum resource within the permit area, the permit holder may apply for either a ‘Retention Lease’ (if the discovery is not economic to extract) or a ‘Production Licence’ (if the discovery can be extracted economically) under Part III of the PGERA.

Environmental requirements

- 4.11 Environmental approvals for onshore unconventional gas are granted in accordance with the PGERA and the Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 (**PGERE Regulations**). There may also be multiple approvals required under other legislation, including:
- clearing permits, works approvals, operating licences for commencing production and producing waste water, solids or gas under the EP Act
 - groundwater abstraction licences under the *Rights in Water and Irrigation Act 1914 (RIWI Act)*⁶³
 - approvals for activities on reserved land from the vested authority of that reserve
 - approvals for disturbing declared rare flora under the *Wildlife Conservation Act 1950*
 - plans and approvals for storage and transportation of bulk dangerous goods by the Department of Commerce.⁶⁴

⁶² The exception to the biannual acreage release are the ‘Special Prospecting Authorities with an Acreage Option’ titles, granted as a means of making preliminary prospectivity assessments in areas where little or no exploration has been undertaken yet; these authorities are limited to six months generally and no drilling is permitted.

⁶³ See paragraph 7.19.

⁶⁴ Department of Mines and Petroleum, *Guidelines for the Preparation and Submission of an Environment Plan*, 28 August 2012, p 9.

4.12 'Environment' is defined broadly in the PGERE Regulations and means:

(a) ecosystems and their constituent parts, including people and communities; and

(b) natural and physical resources; and

(c) the qualities and characteristics of location, places and areas; and

(d) the heritage value of places,

and includes the social, economic and cultural features of the matters mentioned in paragraphs (a), (b), (c) and (d).⁶⁵

4.13 Any petroleum operator wanting to conduct a petroleum activity in Western Australia must prepare and implement an adequate environment plan (EP) for the period of the activity. Prior to commencing the activity, the EP must have been formally assessed by DMP.⁶⁶ When the EP is accepted by DMP, it becomes legally binding and consequences of breaching the EP can include fines or the withdrawal of approval for the EP.⁶⁷

4.14 EPs must include the following information:

- location information and maps
- details of the construction and layout of any facility
- description of the operational details of the proposed activity, including, for example, any hydraulic fracturing proposed
- details of all environmental impacts and risks of the activity, an evaluation of those impacts and risks and how these will be addressed
- details of chemicals and other substances used
- details of progressive rehabilitation objectives and commitments.⁶⁸

⁶⁵ Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 r 4.

⁶⁶ Department of Mines and Petroleum, *Guidelines for the Preparation and Submission of an Environment Plan*, 28 August 2012, p 9.

⁶⁷ Offences in the Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 include: carrying out an activity contrary to the environment plan (r 7); carrying out an activity after having identified a significant risk or impact to the environment that was not provided for in the environment plan (r 8); offences in relation to the contact details of the operator who is carrying out the activity (in Part 5). These three examples all carry maximum penalties of \$10 000 in the regulations.

⁶⁸ Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 r 14.

- 4.15 A diagram illustrating the assessment process is attached to this report at **Appendix 5**.
- 4.16 Operators must also submit a summary EP for public disclosure to the Minister within 10 days of the full EP receiving the Minister's approval. A summary EP must contain basic information relating to the operator, the location of the activity and a general description of the existing environment that may be affected by the activity. The summary EP must also contain summaries only of the following information (which would have been provided in full to DMP as part of the complete EP):
- summary of the construction and layout of any facility, operational details and proposed timetables
 - summary of environmental impacts and risks of the activity and of the implementation strategy (see footnote 272)
 - summary of any consultation already undertaken and any future consultation planned.⁶⁹
- 4.17 If the Minister is not 'reasonably satisfied' that the summary EP submitted meets the criteria in regulation 11(8), the Minister may give the operator written notice to modify the summary and, if the operator does not do so within 10 days, a fine of \$5500 may apply.

AGENCIES THAT REGULATE HYDRAULIC FRACTURING

- 4.18 The regulation of the onshore oil and gas industry in Western Australia is complex and with often-overlapping State and Commonwealth involvement. DMP's summary of the regulatory regime is attached to this report at **Appendix 6**. The main agencies involved are discussed in this chapter.

Department of Mines and Petroleum

- 4.19 DMP is the lead agency that regulates the exploration and production mining industry.
- 4.20 According to the department, the onshore shale gas industry is still in its early stages of development. In 2011, DMP commissioned an independent review of the PGERA and its capacity to effectively regulate shale gas and exploration and production activities.⁷⁰ Dr Tina Hunter's *Regulation of shale, coal seam and tight gas activities in*

⁶⁹ Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 r 11(8).

⁷⁰ Dr T Hunter, *Regulation of shale, coal seam and tight gas activities in Western Australia: Final*, July 2011.

Western Australia (Hunter Report) contained 15 recommendations,⁷¹ including that the department:

undertake to write environmental regulations to regulate onshore petroleum activities, including the recovery of coal seam gas...

undertake to write resource regulations to regulate onshore petroleum activities, including the recovery of coal seam gas...[and]

*ensure the inclusion of management of produced water from abandoned wells in the proposed Environment Regulations and the Resource Management Regulations.*⁷²

- 4.21 DMP's response to the recommendations in the Hunter Report included a 'comprehensive reform package to strengthen the regulatory framework for onshore gas activities.'⁷³ DMP advised the Committee that it is 'progressively implementing' other recommendations in the Hunter Report, including the following action:

*New petroleum safety regulations came into effect in 2010, followed by new petroleum environment regulations in August 2012. These regulations strengthen the obligations on industry in relation to water use management and chemical disclosure...In addition, DMP released new draft petroleum resource management regulations for public comment earlier this month [February 2014].*⁷⁴

New regulations

- 4.22 During the course of this inquiry, DMP released a public consultation draft of regulations made pursuant to the PGERA, intended to deal with administrative issues related to onshore gas mining.⁷⁵ The final version of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 (**PGER Regulations**) came into effect on 1 July 2015. Part 9 of the PGER

⁷¹ The full list of recommendations from the Hunter Report, and DMP's response is attached to this report at **Appendix 7**.

⁷² Dr T Hunter, *Regulation of shale, coal seam and tight gas activities in Western Australia: Final*, July 2011, pp 20-23.

⁷³ Department of Mines and Petroleum, *DMP Response to Report: 'Regulation of Shale, Coal Seam and Tight Gas Activities in Western Australia'*, 31 October 2011, p 2.

⁷⁴ Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, p 2.

⁷⁵ The Hunter Report recommended that DMP draft regulations to better regulate the onshore gas industry. As a result of the Hunter Report, the Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 came into effect on 29 August 2012 to prescribe the contents and procedure for environment plans for mining activities conducted under the PGERA. The Petroleum and Geothermal Energy Resources (Management of Safety) Regulations 2010 dealt with occupational health and safety issues.

Regulations also came into effect on 1 July 2015, but rather as a result of section 57 of the *Petroleum and Energy Legislation Amendment Act 2010*: regulation 2(b) of the PGER Regulations.⁷⁶

4.23 The PGER Regulations deal with well management plans for drilling approvals (including well integrity requirements), ‘good oilfield practice’ (regulation 3(a)(i)), field management plans and the submission and release of information to DMP.⁷⁷ The PGER Regulations replace the content of the Schedule of Onshore Petroleum Exploration and Production Requirements 1991.⁷⁸

4.24 The PGER Regulations are part of a move towards ‘objective-based’ regulation:

*The whole idea of it [objective-based regulation] is that it is transparent, it is risk based, it talks about as low as reasonably practical as far as risk bases go, but it insists that risks are identified with their likelihood, their consequences, how you mitigate them, how you monitor them and how you remediate them should there be any errors or mistakes... We feel that the best way to get the message out both to the public and to the industry is to have open, transparent and consistent legislation around the board.*⁷⁹

4.25 The PGER Regulations represent DMP’s ‘new philosophy’ and captures the full life cycle of a well and a field, from the planning and initial drilling through to decommissioning.⁸⁰ The PGER Regulations contain an ‘Objects’ clause in regulation 3, which is a drafting feature that the Committee notes is seldom used in subsidiary legislation. Regulation 3 outlines the objects of the PGER Regulations as (amongst other things):

to ensure that...the exploration for petroleum or geothermal energy resources...in the State are –

⁷⁶ Section 57 commenced on 1 July 2015. For further discussion of the *Petroleum and Energy Legislation Amendment Act 2010*, refer to Western Australia, Legislative Council, Standing Committee on Uniform Legislation and Statutes Review, Report 47, *Petroleum and Energy Legislation Amendment Bill 2009*, 22 April 2010.

⁷⁷ Department of Mines and Petroleum, *Explanatory Notes for the Consultation Draft of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2014*, February 2014, p 1.

⁷⁸ Department of Mines and Petroleum, *Concordance Table: Schedule of Onshore Petroleum Exploration and Production Requirements 1991*. Available at: <http://www.dmp.wa.gov.au/documents/PD-SBD-ADM-184D.pdf>. Viewed 9 July 2015.

⁷⁹ Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, p 10.

⁸⁰ 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 3.

(i) carried out in a proper and workmanlike manner and...in accordance with good oil-field practice; and

(ii) compatible with the optimum long-term recovery of petroleum and geothermal energy; and

(iii) carried out in a way that reduces the risk of aquifer contamination.

4.26 The Committee considered the PGER Regulations and observes the following in relation to possible implications for hydraulic fracturing:

- A Well Management Plan is required for all petroleum activities (including hydraulic fracturing and well decommissioning) and if the plan does not address the risks associated with that activity, it will not be approved: regulations 10 and 16.
- Operators must apply to the Minister for a Well Management Plan to be approved at least 30 days before the start of any activity, or else a penalty of \$10 000 will apply: regulations 12 and 10.
- A Well Management Plan must provide detailed information about the activity proposed, including how an applicant will monitor well integrity hazards, risks, details of hydraulic fracturing chemicals used and other information specific to the well's operation: regulation 17 and Schedule 1.
- Schedule 1 of the PGER Regulations sets out the information that must be included in a Well Management Plan, including the timetable of activities, chemicals which may be used and details related to any drilling activity (that is, a well's depth, spud date and other information).
- The Well Management Plan must be varied if a significant new detrimental risk occurs or there is potential for it to occur or increase: regulation 20, with a penalty of \$10 000 for non-compliance with the regulation.
- A Field Management Plan is required for all petroleum activities and each well activity must be undertaken consistent with the plan (or else penalties apply).
- A Field Management Plan must include information relating to any aquifers that may be affected by the development of the field, baseline monitoring of groundwater sources, detail of any proposed injection of the resource or of water into underground formations and descriptions of the operator's plans for closure of the field and decommissioning and rehabilitation: regulation 48 and Schedule 3.

- If a ‘significant event’ occurs, the Minister must be notified within two hours by oral notice, then in writing within three days: regulation 62. The Committee notes that the significant events listed in the PGER Regulations can relate to events occurring as a result of hydraulic fracturing, including ‘a new or increased risk’ to either the resource or effects which occur outside the licence area (for example aquifer depletion caused by hydrocarbon extraction).
- Daily activity reports must be submitted to the Minister which provide a detailed summary of any activity carried out at a well, including details of chemicals used and stored onsite, daily costs, contractor contact details, how deep the well has been drilled and so on: regulation 72 and Schedule 5.
- After a well has been completed, a final well activity report must be provided to the Minister within six months of its completion: regulation 73 and Schedules 6 and 7.

Finding 2: The Committee finds that, prior to the commencement of this inquiry, the Department of Mines and Petroleum had taken action to assess the readiness of the agency to deal effectively with the regulation of the onshore shale gas industry, including exploration and production and took action to strengthen its regulatory framework for onshore gas exploration.

Finding 3: The Committee finds that, during the course of this inquiry, the management of well activities, including field management plans and the requirements for baseline monitoring, as set out in the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 has improved, which is a positive development in the regulation of onshore gas activities and hydraulic fracturing in Western Australia.

- 4.27 An EP submitted pursuant to regulation 14 of the PGERE Regulations must include information describing the existing environment that may be affected by the activity and any particular sensitivities of that environment (using the broad definition in the regulations: see paragraph 4.12).
- 4.28 This information can also be described as a baseline study of the environment, as the information may be used to assess the impact of that activity on the environment. The Committee is of the view that without this baseline, pre-activity data, it is difficult to quantify the impact of an activity with certainty.
- 4.29 The description of the environment in the EP must be ‘up-to-date’ and include the following baseline elements:

- information related to the natural environment, including for example, overviews of local geography, geology, water resources, bathymetry⁸¹, oceanography, climate and data on flora and fauna present in the environment status
- information related to the cultural environment, such as Indigenous areas or other heritage issues
- information related to the socio-economic environment, such as fishing activities, shipping, tourism, agricultural land use and proximity to towns and population areas
- information related to local and regional values and sensitivities, for example: cultural and heritage sites, areas of protected or rare and endangered flora or fauna, areas of significant habitat and areas of temporal significance (such as animal breeding grounds).⁸²

4.30 The Committee notes that the level of detail described above demonstrates the importance of pre-activity assessment of the environment.

Finding 4: The Committee finds that the information required in environment plans lodged pursuant to regulation 14 of the Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 is important baseline information which is essential to regulate any ongoing effects of hydraulic fracturing on the environment.

4.31 The Committee has investigated the quantum of penalties which are available in the PGER Regulations and are authorised by the powers in the PGERA. Section 153(3) of the PGERA imposes a maximum amount for fines that can be prescribed in regulations made under the Act, as follows:

The regulations may provide, in respect of an offence against the regulations, for the imposition of –

(a) a fine not exceeding \$10 000; or

(b) a fine not exceeding that amount for each day on which the offence occurs.

⁸¹ Bathymetry is the study of and mapping of seafloor topography, including measuring the depth of the ocean.

⁸² Department of Mines and Petroleum, *Guidelines for the Preparation and Submission of an Environment Plan*, 28 August 2012, pp 33-34.

4.32 Some of the offences and corresponding penalties in the PGER Regulations include:

- undertaking well activity without an approved well management plan – a fine of \$10 000: regulation 10(1)
- not making an application for revising the well management plan where there has been a change in the understanding of the geology or formation, an occurrence or potential occurrence of a ‘significant new detrimental risk’ on the integrity of a well or a significant increase in an existing detrimental risk – a fine of \$10 000: regulation 20
- where there is a new well integrity hazard or a significant increase in an existing risk for a well, the title holder must control the well integrity hazard or risk, or an offence is committed – a fine of \$10 000: regulation 33
- if more than two hours have elapsed since a ‘significant event’ has occurred and the title holder has not yet orally notified the Minister – a fine of \$10 000: regulation 62(3)
- accounts, records and other documents must be kept securely and be reasonably practicable to retrieve – a fine of \$4000: regulations 65 and 66
- failure to provide the Minister with the daily well activity report by midday of the next day – a fine of \$7000: regulation 72.

4.33 The Committee queried the penalty amounts prescribed in the PGER Regulations with DMP, as the amounts do not seem to be sufficient to act as a deterrent, given the high costs and capital often involved in the resources industry:

***Hon BRIAN ELLIS:** You did mention penalties. I would just like you to explain, then, how you arrived at your maximum penalty of \$10 000 for any offences under these regulations when you take into account the amount of capital involved in this industry. Can you explain how you came up with that maximum?*

***Mr Sellers:** It is a very good question. That is the maximum we can apply under current rules and legislation. Also, at the same time, we have another consultative process about our penalties overall and, in there, there are suggestions to take them up to the more appropriate corporate level. Once that has been settled, we see ourselves going back and adjusting those penalties up to a more appropriate base, but we have to consult and get the approval to do that prior to setting them on the existing.*

*So, the existing was compelled by the legislation that is in place at the moment.*⁸³

- 4.34 The Committee is of the view that the maximum amount outlined in section 153(3) of the PGERA is insufficient to act as a deterrent for resource companies involved in the production of unconventional gas.

Finding 5: The Committee finds that the current penalties included in the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015, which range from penalties of \$4000 to a maximum of \$10 000, are not adequate to effectively deter the behaviour outlined in the regulations.

- 4.35 The Committee also makes the following recommendation in relation to the penalty regime in the PGER Regulations.

Recommendation 1: The Committee recommends that the Government amend section 153(3) of the *Petroleum and Geothermal Energy Resources Act 1967* to increase the maximum fines permitted in regulations made under the Act to a more appropriate level.

Part 9 of the PGER Regulations: release of technical information about petroleum and geothermal energy resources

- 4.36 Part 9 of the PGER Regulations (in particular Divisions 1, 2 and 3) deal with the disclosure and publication of information which may relate directly to hydraulic fracturing activities in Western Australia.
- 4.37 The Committee has heard concern, fear and mistrust that information relating to well integrity, methane leaks or public safety may not be released to the public. For example, submissions stated that:⁸⁴

*No industry in WA should be allowed to maintain secrecy about its emissions into the environment.*⁸⁵

*In West Australia...there is a culture of secrecy, cost cutting, lack of transparency, avoidance of responsibility to other [sic] than to their shareholders.*⁸⁶

⁸³ Hon Brian Ellis, Member, Standing Committee on Environment and Public Affairs and Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, pp 10-11.

⁸⁴ Discussed further at CHAPTER 6 and CHAPTER 10.

⁸⁵ Submission 23 from Roy Oldham, 17 September 2013, p 1.

*To date the petroleum industry has had preferential legislation, and is less regulated than other types of mining... There is no transparency.*⁸⁷

*Who do we trust for measuring and recording data when something goes wrong with a fracking procedure?*⁸⁸

*Under the current regime, information... is treated as 'commercial in confidence' and as such is not available or discoverable, even by Parliament.*⁸⁹

4.38 Given these community concerns, the Committee examined the PGER Regulations to ascertain if information related to hydraulic fracturing will be released publicly. Part 9 of the PGER Regulations aims to 'protect confidential information appropriately, while allowing for its use to exploit and manage the resource.'⁹⁰ Information will not necessarily be automatically made publicly available or released by the Minister at a particular time.

4.39 The department previously advised that:

*The primary aim of certainly this department is open data – get the data out; make it available. It is good not only for the public interest, but it is also good for the industry to see how wells were drilled and what happened on those wells.*⁹¹ [Committee emphasis]

4.40 Part 9 of the PGER Regulations includes new definitions of the various types of information that may be held by resource companies in relation to petroleum and geothermal energy resource activities. The definitions of this information dictate what may be done with the information, for example, whether the information can be disclosed publicly. The Committee has summarised the main types of information defined in Part 9 of the PGER Regulations below and has produced the following table:

⁸⁶ Submission 28 from Patricia McAuliffe, 18 September 2013, p 18.

⁸⁷ Submission 55 from Gingin Water Group Inc., 19 September 2013, p 3.

⁸⁸ Submission 74 from Christine and Kingsley Smith, 20 September 2013, p 5.

⁸⁹ Submission 110 from Conservation Council of Western Australia (Inc.), 2 October 2013.

⁹⁰ Department of Mines and Petroleum, *Explanatory Notes for the Consultation Draft of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2014*, February 2014, p 12.

⁹¹ Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, p 12.

Type of information	Definition
<i>Basic information</i>	Documentary information that is not interpretative information
<i>Disclosable information</i>	Documentary information that is not permanently confidential information
<i>Excluded information</i>	Defined in regulation 82: information which relates to technical qualifications or technical advice, financial resources information and 15 types of documents listed in r82(3); has retrospective effect
<i>Interpretative information</i>	Defined in regulation 84: is information given to the Minister which is considered as/advised to be a conclusion or opinion drawn wholly/partly from other documentary information.
<i>Permanently confidential information</i>	Defined in regulation 83: sets out four situations in which documentary information is permanently confidential: <ul style="list-style-type: none"> ◦ excluded information is always permanently confidential: r83(2) ◦ if the Minister considers information to be a trade secret or that the disclosure ‘would or could reasonably be expected to adversely affect the person’s business, commercial or financial affairs’: r83(3) ◦ if the person told the Minister in writing that the person classified the information as a trade secret or that the disclosure ‘would or could reasonably be expected to adversely affect the person’s business, commercial or financial affairs’ and the Minister did not dispute this in writing: r83(4) ◦ if the person told the Minister that the person classified the information as a trade secret or that the disclosure ‘would or could reasonably be expected to adversely affect the person’s business, commercial or financial affairs’ and the Minister disputed this by written notice and the time for objection to the Minister’s notice has not yet elapsed or an objection has been lodged and remains in force: r83(5).

4.41 The Committee questioned DMP on the possible unintended consequences of permanently confidential information in regulation 83 (then draft regulation 85):

Hon STEPHEN DAWSON: ...could this draft regulation 85 be used by companies who do not want to disclose what chemicals are in their fracking fluids?

Mr Sellers: No.

Dr Gorey: Certainly, that is not the intent. With the draft regulations going out, very clearly what we want to do is maintain the disclosure integrity of the environmental regulations, which have full chemical disclosure.

Hon STEPHEN DAWSON: So it is not the intent, but it could potentially happen...

*Mr Sellers: on the first part of the question, they will put a case, we would look at it and we would say, on transparency, because of our other regs, clearly no.*⁹²

4.42 Since the PGER Regulations commenced on 1 July 2015, there have been no requests for the Minister to decide that a specific piece of information is permanently confidential information. Prior to the PGER Regulations, section 112 (now repealed) of the PGERA permitted an interested person to request that the Minister keep information permanently confidential (by objecting to the automatic publication of information after five years). Under this previous regime, there was only one known example where a company requested that the Minister keep data permanently confidential.⁹³

4.43 The Committee explored the issue of transparency and disclosure of information further with DMP and has heard that DMP is:

*moving from a world where most of this information was confidential because there actually was not a level of interest in it. So we are, as an organisation, moving to making our information available and a commitment to transparency...*⁹⁴

4.44 The Committee notes that Part 9 of the PGER Regulations is currently the only reference to a procedure for disclosing information in subsidiary legislation under the PGERA. There are no penalties related to the disclosure (or non-disclosure) of information in the PGER Regulations.

Finding 6: The Committee finds that Part 9 of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015, in particular regulation 83, does not meet the Department of Mines and Petroleum's stated intention of transparent and open communication and engagement with the public regarding hydraulic fracturing in this State.

Recommendation 2: The Committee recommends that regulation 83 of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 be amended, in particular the deletion of regulations 83(4) and 83(5).

⁹² Hon Stephen Dawson, Deputy Chair and Mr Richard Sellers, Director General, Department of Mines and Petroleum and Dr Phil Gorey, Executive Director Environment, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, pp 11-12.

⁹³ Letter from Mr Richard Sellers, Director General, Department of Mines and Petroleum, 8 September 2015, p 4.

⁹⁴ Ms Michelle Andrews, Deputy Director General Strategic Policy, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 4.

Auditor General's reports

4.45 The Office of the Auditor General (OAG) has released two reports related to how DMP monitors compliance with mining conditions: 2011's *Ensuring Compliance with Conditions on Mining (OAG 2011 Report)* and *Ensuring Compliance with Conditions on Mining – Follow Up (OAG 2014 Report)*, published in November 2014.⁹⁵

4.46 The Auditor General initially identified weaknesses in the effective monitoring and enforcement of conditions placed on mining approvals. The OAG 2011 Report found that:

*monitoring and enforcement of environmental conditions need significant improvement. Currently, agencies can provide little assurance that the conditions are being met.*⁹⁶

4.47 The Auditor General focused on DMP's annual environmental reporting requirement for operators, its mine inspection regime and rehabilitation planning and found that DMP's 'approach to enforcing environmental conditions is to take the minimum action required to obtain industry cooperation and compliance.'⁹⁷ DMP acknowledged the failings identified in the OAG 2011 report and committed to reform its compliance operations 'to provide greater assurance that mining conditions are being adhered to.'⁹⁸

4.48 The Committee notes that the follow-up report from the OAG three years later found that there had been 'significant improvement' by DMP and that:

*improved assessment, inspection and reporting processes mean that the Department of Mines and Petroleum (DMP) has greater capacity to assess whether conditions placed on mines are being met.*⁹⁹

4.49 In 2014, the Auditor General found that DMP had addressed the weaknesses in its planning, monitoring and inspection of mines since 2011, as well as improving its inspection and reporting regime. With regard to mine inspections, the OAG 2014

⁹⁵ The first report is: Western Australia, Office of the Auditor General, *Ensuring Compliance with Conditions on Mining*, 28 September 2011. The second report is: Western Australia, Office of the Auditor General, *Ensuring Compliance with Conditions on Mining – Follow Up*, 19 November 2014.

⁹⁶ Office of the Auditor General, *Ensuring Compliance with Conditions on Mining*, 28 September 2011, p 8.

⁹⁷ Ibid, p 8.

⁹⁸ Ibid, p 10.

⁹⁹ Office of the Auditor General, *Ensuring Compliance with Conditions on Mining – Follow Up*, 19 November 2014, p 6.

Report noted that ‘all sites assessed as “high risk” will be inspected each year’ along with 20 per cent of all other sites.¹⁰⁰ According to the OAG:

*in 2014-15 DMP will conduct 181 inspections...and 130 desk-top reviews. In total they will reach 45 per cent of mines.*¹⁰¹

- 4.50 Whilst the majority of the sites to be inspected are not subject to hydraulic fracturing, the Committee notes that any general improvement in DMP’s mining compliance activities will have a flow-on effect on unconventional gas development in the State.

Finding 7: The Committee finds that the Department of Mines and Petroleum has improved its monitoring and compliance activities following the Auditor General’s 2011 report, ‘Ensuring Compliance with Conditions on Mining’, that had found deficiencies in its compliance with conditions on mining.

A whole of government approach to unconventional gas regulation

- 4.51 During the course of this inquiry, DMP has been developing a document to outline the State’s regulatory framework and the roles and responsibilities of all agencies involved in the regulation of hydraulic fracturing, which was released publicly in late 2015.¹⁰²

- 4.52 The Committee notes that the ‘Guide to the Regulatory Framework for Shale and Tight Gas in Western Australia: A Whole-of-Government Approach’ (**2015 Framework**) is a further useful development to inform the community of the interaction between the various departments and agencies involved in the regulation of hydraulic fracturing. The aim of the 2015 Framework is to:

- Provide an account of the State’s assessment and regulation processes for shale and tight gas projects.
- Provide clarity regarding the State’s requirements and the legislation and regulations through which those requirements are enforced.
- Provide the regulatory criteria for assessment, approval and compliance to enable the public to reach an informed opinion.¹⁰³

¹⁰⁰ Office of the Auditor General, *Ensuring Compliance with Conditions on Mining – Follow Up*, 19 November 2014, p 7.

¹⁰¹ Ibid, p 17.

¹⁰² 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*, October 2015.

¹⁰³ Ibid, p 5.

4.53 The 2015 Framework outlines the agreements that exist between DMP, as the lead regulator of petroleum activities in Western Australia, and the following regulatory agencies:

- Memorandum of Understanding and referral procedure with the Environmental Protection Agency (**EPA**) (see paragraphs 4.57 and 4.69).
- Administrative agreement with the Department of Environment Regulation in relation to native vegetation clearing and clearing permits.
- Consultation with the Department of Parks and Wildlife in relation to petroleum activities on reserved land managed under the *Conservation and Land Management Act 1984*.
- Agreement with the Department of Health in relation to issues of potential public health risks or significant public interest or where a public drinking water source supply is polluted (see paragraph 4.106).
- Memorandum of Understanding with the Radiological Council for the regulation of naturally occurring radioactive materials (**NORM**) associated with the petroleum industry.
- Agreement with the Department of Water to refer petroleum proposals where they may pose a significant risk to water resources or are on reserved lands vested in the Minister for Water (see paragraph 4.85).
- Memorandum of Understanding with the Department of Aboriginal Affairs in relation to Aboriginal heritage sites in areas of proposed exploration or development.
- Memorandum of Understanding with the Western Australian Planning Commission and the Department of Planning in relation to the possible impact of planning proposals or schemes on mineral or petroleum resources.¹⁰⁴

4.54 The Committee notes that DMP further identifies the Department of Water, the EPA and the Office of the EPA as the ‘major regulatory agencies’ involved in the onshore shale and tight gas industry.¹⁰⁵

¹⁰⁴ 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*, October 2015, pp 21-24.

¹⁰⁵ *Ibid*, p 14.

Environmental Protection Authority

- 4.55 One of the EPA's primary roles is to assess the environmental impacts of, and make recommendations to the Minister for Environment on, proposals that may have a significant impact on the environment.¹⁰⁶ This includes proposed hydraulic fracturing operations in Western Australia. Part IV of the *Environmental Protection Act 1986* deals with the EPA's assessment of proposals and referrals to the EPA.
- 4.56 In terms of its broader oversight role, the EPA advised that it maintains a watching brief on developments in hydraulic fracturing in Western Australia, other Australian jurisdictions and overseas and provides advice to DMP and other organisations.¹⁰⁷

Environmental Impact Assessments in the Environmental Protection Act 1986

- 4.57 Part IV of the *Environmental Protection Act 1986 (EP Act)* deals with environmental impact assessments and the conditions under which proposals or schemes may be referred to the EPA for assessment. There are two categories of proposals defined in section 37B of the EP Act which may be referred to the EPA:
- a 'significant proposal' is a proposal likely, if implemented, to have a significant effect on the environment
 - a 'strategic proposal' which identifies a future proposal that will be a significant proposal or future proposals likely, if implemented in combination with each other, to have a significant effect on the environment.¹⁰⁸
- 4.58 The category of strategic proposal therefore implies an assessment of the cumulative environmental impacts of a proposal (or future proposal). For example, the EPA will consider broader cumulative impacts to the environment if a production project is referred, such as associated infrastructure, including gas processing hubs, pipelines, access tracks and changes in land use.¹⁰⁹
- 4.59 In most circumstances, any person may refer a significant proposal to the EPA for assessment (except for an assessed scheme or where the proposal is currently referred): sections 38(2) and (5j) of the EP Act. The proponent of a strategic proposal may refer the proposal to the EPA and the Minister for the Environment also has the

¹⁰⁶ Submission 117 from Environmental Protection Authority, 25 March 2014, p 1.

¹⁰⁷ Ibid, p 1.

¹⁰⁸ The definition of 'strategic proposal' was inserted in 2003, with the intention that the EPA 'can assess the strategic proposal and recommend the conditions that should be applied to the future proposals that it identifies (eg the future exploration wells)': Environmental Protection Amendment Bill 2002, Explanatory Memorandum, p 2.

¹⁰⁹ Environmental Protection Authority, *Environmental Protection Bulletin No. 22: Hydraulic fracturing for onshore natural gas from shale and tight rocks*, December 2014, p 3.

power to refer proposals if it appears that there is ‘public concern about the likely effects of the proposal’: sections 38(3) and (4) of the EP Act.

4.60 It is important to note that the EPA also has the power to compel a proponent or a decision-making authority to refer a proposal to the EPA, if it considers that the proposal is significant or it involves a significant discharge of waste or a significant emission of noise, odour or electromagnetic radiation.¹¹⁰ The Committee notes that the EPA therefore has the power to override the issue of a decision-making authority or proponent to not refer a proposal for assessment.

4.61 Once a proposal has been referred to the EPA (in any of the circumstances listed in section 38 of the EP Act), the EPA must decide whether to assess the proposal or not. If the EPA decides not to assess a proposal, it may still give advice and make recommendations on the environmental aspects of the proposal to the proponent or any other relevant person or authority: section 39A(7) of the EP Act.

4.62 However, if the EPA does assess the proposal, it may take the following action during the assessment:

- obtain information from any person as the EPA requires
- compel the proponent to obtain a contaminated sites report from an auditor
- compel the proponent to undertake an environmental review for the EPA
- conduct a public inquiry or appoint a committee under the *Royal Commission Act 1968*, subject to the Minister for Environment’s approval
- any other investigations or inquiries as the EPA thinks fit.¹¹¹

4.63 If the DMP has referred a proposal to the EPA, it cannot make a decision to implement that proposal until the EPA has completed its assessment process: section 41 of the EP Act.

Environmental factors considered when assessing a proposal

4.64 If the EPA has decided to assess a proposal, it must prepare an assessment report for the Minister for Environment with the outcome and the ‘key environmental factors’

¹¹⁰ EP Act ss 38(5c) and Environmental Protection Regulations 1987 r 2C.

¹¹¹ EP Act ss 40(2)(a)-(2a). The EPA may also make any of the information obtained pursuant to section 40(2) available for public review, excluding any confidential information contained therein.

that it considered during the assessment. The environmental factors and objectives that the EPA has adopted are outlined in **Figure 10**.¹¹²

4.65 **Figure 11** (at paragraph 4.84) outlines the five key environmental factors which are most likely to require consideration when a proposal involves hydraulic fracturing.

4.66 The EPA considers that a number of the potential impacts of hydraulic fracturing are similar to those associated with many other types of proposals, including land clearing, water abstraction, the release of greenhouse gas emissions and impacts related to noise and dust generation. The EPA does not consider hydraulic fracturing to be unique in its potential impacts and will ‘consider such impacts associated with proposals involving hydraulic fracturing in the same way as other proposals.’¹¹³

4.67 The EPA has submitted that:

it is inevitable that we will formally assess a hydraulic fracturing proposal, but it will be based on our determination about whether that proposal is significant. In the meantime, while government is getting its regulatory house in order, isolating those critical issues will be important in understanding whether there are cumulative impacts and risks and how they might be managed...

*we identified that there are going to be other issues – cumulative impacts and risks – that will need to be managed over time. But the industry is a nascent one and we are in good shape to manage the issues and risks associated with that activity.*¹¹⁴

¹¹² Table reproduced from Environmental Protection Authority, *Environmental Assessment Guideline No. 8: Environmental Factors and Objectives*, June 2013, pp 3-4.

¹¹³ Environmental Protection Authority, *Environmental Protection Bulletin No. 22: Hydraulic fracturing for onshore natural gas from shale and tight rocks*, December 2014, p 3.

¹¹⁴ Dr Paul Vogel, Chairman, Environmental Protection Authority, *Transcript of Evidence*, 31 March 2014, pp 4-5.

Theme	Factor	Objective	Theme	Factor	Objective
Sea	Benthic Communities and Habitat	To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.	Inland Waters Environmental Quality	Air Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.
	Coastal Processes	To maintain the morphology of the subtidal, intertidal and supratidal zones and the local geophysical processes that shape them.			
	Marine Environmental Quality	To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.	Amenity	Heritage	To ensure that impacts to amenity are reduced as low as reasonably practicable.
	Marine Fauna	To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.			
Land	Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	Human Health	Human Health	To ensure that human health is not adversely affected.
	Landforms	To maintain the variety, integrity, ecological functions and environmental values of landforms and soils.			
	Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	Offsets	Rehabilitation and Closure	To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.
	Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.			
	Terrestrial Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	To ensure that premises are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.		
	Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.			
Water					

Figure 10. EPA's framework for environmental factors and objectives [Source: Environmental Assessment Guideline No. 8, June 2013]

4.68 When making a decision not to assess a proposal, the EPA will take into account the following considerations:

- If there is early confidence that none of the factors are key environmental factors, the proposal will not be assessed by the EPA.
- Where proposals are not so significant as to warrant an environmental impact assessment, and there is an alternate regulatory process which can ensure the environmental objectives for relevant factors can be met, the proposal will not be assessed by the EPA.
- As soon as there is confidence that a factor is not a key environmental factor, that factor will receive no further consideration by the EPA.
- The EPA will avoid duplication with other regulatory processes where it has confidence that the regulatory process can ensure the environmental objective for any relevant factor will be met.¹¹⁵

Memorandum of Understanding with Department of Mines and Petroleum

4.69 On 29 June 2009, EPA and DMP signed a Memorandum of Understanding (MOU) for the purposes of establishing:

*an efficient and transparent administrative process for the Department of Mines and Petroleum to refer environmentally significant mineral, petroleum and geothermal proposals to the Environmental Protection Authority, pursuant to Part IV of the Environmental Protection Act 1986.*¹¹⁶

4.70 Schedule 2 of the MOU outlines the criteria for referral of onshore petroleum activities and is attached to this report at **Appendix 8**. There are several triggers outlined in Schedules 2 and 3 of the MOU which will require DMP to liaise with the EPA or refer a proposal for assessment, irrespective of the potential to cause significant environmental impact.¹¹⁷

4.71 The MOU outlines the administrative arrangements between the two agencies in the referral of proposals under section 38 of the EP Act and includes provision for information sharing, consultation on policy changes and meetings for specific

¹¹⁵ Environmental Protection Authority, *Environmental Assessment Guideline No. 9: Application of a significance framework in the EIA process*, January 2015, p 2.

¹¹⁶ Department of Mines and Petroleum and Environmental Protection Authority, *Memorandum of Understanding*, 26 June 2009, p 1.

¹¹⁷ Department of Mines and Petroleum, *Guidelines for the Preparation and Submission of an Environment Plan*, 28 August 2012, p 11.

proposals that are likely to be referred.¹¹⁸ Section 38 of the EP Act outlines the procedure for referring proposals to the EPA for environmental impact assessment.

- 4.72 The Committee raised concerns with the EPA that the power to refer environmental proposals to the EPA is at the discretion of the DMP, which could then lead to a situation where ‘if the DMP considers it not to be a significant impact, that is the end of it.’¹¹⁹
- 4.73 The EPA’s view is that ‘significant impact’ will prevail and the EPA advises that it has a good working relationship with DMP:

they [DMP] pick up the phone. There is substantial guidance in both our environmental protection bulletin on hydraulic fracturing and the MOU, but if there is any doubt in the DMP officer’s mind, we have said to them, “Pick up the phone”, and that is indeed what happens. They pick up the phone and have a discussion: “This is likely to occur there. This is our view. Do you think we should refer it?” There is a discussion, and a judgement is made about whether it needs to be referred or not...

The EPA from time to time might have a different view about what is significant, but it will convey those views to the DMP and expect it to be referred.

If there is a difference of views about significance, the EPA’s view will prevail, and we will make a judgement about significance and whether or not it needs to be formally assessed.¹²⁰

- 4.74 DMP has also confirmed its ‘well established strong working relationship’ with the EPA but also advised the Committee that the department has commenced a review of the referral procedures to see if they can be ‘further strengthened in the context of shale and tight gas.’¹²¹ In DMP’s experience, matters are most often referred to the EPA by the proponents themselves and often, ‘where there is a genuine public interest or an issue that needs to be threshed out by the EPA...both the projects [proponent] themselves and third parties do take that option.’¹²²

¹¹⁸ Department of Mines and Petroleum and Environmental Protection Authority, *Memorandum of Understanding*, 26 June 2009, pp 2-3.

¹¹⁹ Hon Brian Ellis MLC, Member, Standing Committee on Environment and Public Affairs, *Transcript of Evidence*, 31 March 2014, p 7.

¹²⁰ Dr Paul Vogel, Chairman, Environmental Protection Authority, *Transcript of Evidence*, 31 March 2014, pp 7-8.

¹²¹ Ms Michelle Andrews, Deputy Director General Strategic Policy, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 1.

¹²² Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 2.

- 4.75 Whilst the Committee appreciates EPA's evidence that the process is 'working very well', it remains concerned that the onus of referring proposals lies with DMP and relies upon informal interagency cooperation rather than established procedures.
- 4.76 Given the concern expressed in the community regarding the potential impact on the environment of hydraulic fracturing proposals, the Committee's view is that the MOU should be amended to formally reflect the process described to the Committee at paragraph 4.73.

Finding 8: The Committee finds that there is an inconsistency between the terms of referral in the Memorandum of Understanding between the Department of Mines and Petroleum and the Environmental Protection Authority and the informal interagency discussions which take place prior to proposals being referred under section 38 of the *Environmental Protection Act 1986*.

Recommendation 3: The Committee recommends that the Memorandum of Understanding between the Department of Mines and Petroleum and the Environmental Protection Agency be amended to require the Department of Mines and Petroleum to refer all proposals under section 38 of the *Environmental Protection Act 1986* to the Environmental Protection Agency.

Significant impact on the environment

- 4.77 The EPA submitted that its involvement in environmental matters is limited to its statutory powers under Part IV of the EP Act to assess whether a proposal is likely to have a significant effect on the environment.¹²³
- 4.78 The EP Act does not define 'significant effect'. The EPA has a 'significance test' set out in its 'Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012'.¹²⁴ The procedure provides that the EPA:

makes a decision about whether a proposal is likely to have a significant effect on the environment using professional judgement, which is gained through knowledge and experience in the application of EIA [Environmental Impact Assessment]...

some of the factors to which the EPA may have regard to include –

(a) values, sensitivity and quality of the environment which is likely to be impacted;

¹²³ See paragraph 4.57 onwards.

¹²⁴ Published in the *Western Australian Government Gazette* on 7 December 2012.

- (b) extent (intensity, duration, magnitude and geographic footprint) of the likely impacts;
- (c) consequence of the likely impacts (or change);
- (d) resilience of the environment to cope with the impacts or change;
- (e) cumulative impact with other projects;
- (f) level of confidence in the prediction of impacts and the success of proposed mitigation;
- (g) objects of the Act, policies, guidelines, procedures and standards against which a proposal can be assessed;
- (h) presence of strategic planning policy framework;
- (i) 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
- (j) public concern about the likely effect of the proposal, if implemented, on the environment.¹²⁵

4.79 Guidance for proponents is provided through EPA's Environmental Protection Bulletins (see paragraph 4.84).

4.80 When the EPA has determined if a proposal has a significant impact or not, the subsequent procedure will depend upon the determination made. The EPA advised that:

if it [the EPA] forms a view that it [the proposal] is not so significant that it warrants formal assessment and can be managed by other regulators, it will document that in a statement of reasons...

If the EPA forms the view that the proposal is potentially significant, it can then decide to formally assess. That means that there is a requirement that a level of assessment is set, and that level of assessment can be either an assessment on proponent information or it can be a public environmental review, or it could be on referral information that the answer is environmentally unacceptable on referral information and then the procedural fairness process ensues if the EPA recommends so.

¹²⁵ Western Australian Government Gazette, No. 223, *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures*, 7 December 2012, p 5944.

*If it falls into the formal process, depending on whether it is an assessment on proponent information or a public environmental review, there will be an environmental review document that will either have to be consulted with key stakeholders or the community will need to be consulted more extensively for the public environmental review process. It then goes to consideration for EPA.*¹²⁶

4.81 The EPA had considered six proposals which involved hydraulic fracturing by March 2014 and, in each case, determined that the environmental impacts were ‘not so significant to warrant formal environmental impact assessment under the Act.’¹²⁷

4.82 The EPA acknowledged at a hearing that the public may not always be aware of the statutory basis for its decisions not to formally assess an environmental proposal:

*The other thing I would say is that the concept of significance [in Part IV of the Environmental Protection Act 1986] is sometimes in the eye of the beholder but we need to make a judgement about whether a proposal is significant or not.*¹²⁸

4.83 The EPA addressed this disparity between the EPA’s statutory obligations and community expectations in the EPA’s *Annual Report 2013-14*. The EPA advises that only a small proportion of referrals are formally assessed because:

*the EPA is required by law to assess only those proposals and schemes that are likely to have a **significant** effect on the environment...Clearly, community views can differ greatly on what is significant.*

Importantly, when the EPA decides not to assess a proposal, it is not saying there are no environmental issues at stake...

*These are not simple decisions.*¹²⁹

4.84 In 2014, the EPA issued a new Environmental Protection Bulletin on ‘Hydraulic fracturing for onshore natural gas from shale and tight rocks.’¹³⁰ The updated bulletin

¹²⁶ Dr Paul Vogel, Chairman, Environmental Protection Authority, *Transcript of Evidence*, 31 March 2014, pp 3-4.

¹²⁷ Submission 117 from Environmental Protection Authority, 25 March 2014, p 2. Attachment A to EPA’s submission contains details of all shale and tight gas referrals since 2011.

¹²⁸ Dr Paul Vogel, Chairman, Environmental Protection Authority, *Transcript of Evidence*, 31 March 2014, p 2.

¹²⁹ Environmental Protection Authority, *Annual Report 2013-14*, p 13.

outlines the circumstances in which the EPA will assess proposals and makes explicit reference to the EPA’s expectations with respect to hydraulic fracturing activities in a comprehensive table format: see **Figure 11**.

Factors	Hydrological Processes	Inland Waters Environmental Quality	Terrestrial Environmental Quality	Human Health	Rehabilitation and Closure
	Objective: To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.	Objective: To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.	Objective: To maintain the quality of land and soils so that the environmental values, both ecological and social, are protected.	Objective: To ensure that human health is not adversely affected.	Objective: To ensure that premises are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.
Applicable project components and activities	Groundwater abstraction for fracking water supplies. Drilling and construction of wells to be fracked. Injection of fracking fluids.	Injection of fracking fluids, Storage and handling of fracking fluids and additives (e.g. chemicals and proppants). Storage and disposal of flowback fracking fluids and produced formation water.	Storage and handling of fracking fluids and additives. Storage and disposal of flowback fracking fluids and produced formation water.	Injection of fracking fluids. Storage and handling of fracking fluids and additives. Storage and disposal of flowback fracking fluids and produced formation water.	Well closure and decommissioning. Disposal of contaminated wastes. Storage pond and site rehabilitation.
Potential environmental impacts	Changed water regimes impacting on groundwater dependent ecosystems. Induced seismicity. Intersection and unintended connection of aquifers, impacting on flow regimes, aquifer quality and water users.	Contamination of groundwater with fracking fluids and cross-contamination of aquifers through casing failure, breaching seals or hydrogeological faults. Surface water contamination directly or through pond leakage or overflow.	Contamination of soils.	Contamination of drinking water sources, public and private, and other water supplies.	Contamination of soils, surface water and groundwaters.

Figure 11. Information requirements to support the environmental impact assessment of hydraulic fracturing activities [Source: Environmental Protection Bulletin No. 22, December 2014]

Finding 9: The Committee finds that the Environmental Protection Authority’s process of assessing proposals according to the *Environmental Protection Act 1986* is well-established and satisfies the legislative requirements of section 38 of the Act and its role as an advisory agency to the Minister for the Environment.

Finding 10: The Committee finds that the Environmental Protection Authority has a mature understanding of its statutory obligations and that, during the course of this inquiry, the agency has set in place procedures to better explain its role to the community.

130 Environmental Protection Authority, *Environmental Protection Bulletin No. 22: Hydraulic fracturing for onshore natural gas from shale and tight rocks*, 17 December 2014. The previous version has been withdrawn from EPA and DMP websites: *Environmental Protection Bulletin No. 15: Hydraulic fracturing of gas reserves*, 5 September 2011. Available (via Norwest Energy website) at: <http://www.norwestenergy.com.au/assets/files/Industry%20News/2011%2009%20EPA%20-%20Hydraulic%20fracturing%20of%20gas%20reserves.pdf>. Viewed 5 May 2015.

Finding 11: The Committee finds that the decision by the Environmental Protection Authority to not conduct a formal assessment of a proposal pursuant to the requirements of section 38 of the *Environmental Protection Act 1986* is a decision pursuant to that statute.

Department of Water and Water Corporation

- 4.85 The Department of Water (**DoW**) administers the RIWI Act and associated regulations, which are the primary legislative tools to provide for the regulation, management, use and protection of water resources in Western Australia.¹³¹ DoW provides for the protection of public drinking water source areas (**PDWSA**) in rural areas through the *Country Areas Water Supply Act 1947* and in the metropolitan area using the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* (see CHAPTER 7).
- 4.86 The Water Corporation is responsible for ‘the supply of safe drinking water to its customers’ and operates under a licence obtained from the Economic Regulation Authority.¹³² The Water Corporation operates over 700 groundwater wells, 114 surface sources and two large seawater desalination plants and supplies over 350 billion litres of water to 2.2 million customers across the State every year.¹³³
- 4.87 DoW identifies its primary role with regard to hydraulic fracturing as the regulator of water access approvals for groundwater or surface water resources.¹³⁴ As previously noted, water is an essential part of the hydraulic fracturing process in Western Australia.
- 4.88 In order to access or take water from a proclaimed area, DoW may issue a licence in accordance with the RIWI Act, specifically the matters outlined in Schedule 1 of that Act and regulations 7(2) and 35(2) of the Rights in Water and Irrigation Regulations 2000.¹³⁵
- 4.89 The DoW clarified the licensing regime at a hearing:

The CHAIRMAN: This is the point of ambiguity: I understand from your submission that all wells and bores in proclaimed groundwater areas have to be licensed.

¹³¹ Submission 115 from Department of Water, 15 October 2013, p 4.

¹³² Submission 47 from Water Corporation, 20 September 2013, p 7.

¹³³ Mr Ashley Vincent, General Manager Planning and Capability Group, Water Corporation, *Transcript of Evidence*, 10 February 2014, p 2.

¹³⁴ Submission 115 from Department of Water, 15 October 2013, p 3.

¹³⁵ *Ibid*, p 5. Attachment 2 of the submission (at p 17) provides further detail of how the Department of Water interprets and assesses the criteria for granting a groundwater access licence.

*Mr Bagdon: That is wells for the taking of water. The wells used for petroleum exploration and subsequently fracking are not the taking of water. They pass through the aquifer; they do not actually take water from the aquifer. If, for purposes of drilling, they wish to take water, we would be involved in the assessment and licensing of that take but not of a well for petroleum exploration.*¹³⁶

- 4.90 DoW is involved with DMP in an Inter-agency Committee on Shale and Tight Gas, whose membership also includes EPA, Department of Agriculture and Food, Department of Environment Regulation and Department of Health. The committee's purpose is to provide a forum for key agencies to work together and share information, identify issues and ongoing improvements to the regulatory framework and to provide advice on specific proposals, amongst other things.¹³⁷
- 4.91 In August 2015, DMP and DoW entered into an administrative agreement for onshore petroleum and geothermal activities in the State to 'facilitate ongoing collaboration and cooperation between the two departments.'¹³⁸ The principles that DMP and DoW have agreed to include, amongst other things, that:
- water resources and petroleum and geothermal resources in their natural state belong to the people of Western Australia
 - the protection of water resources is a priority for the Government of Western Australia
 - information sharing and collaboration are fundamental aspects of all activities between the departments.¹³⁹
- 4.92 The agreement stipulates that DMP will seek advice from DoW prior to releasing acreage titles (see paragraph 4.9) in relation to any matters or specific information that relates to water sources within the petroleum acreage.
- 4.93 Further, where DMP receives an EP that proposes petroleum activities (such as hydraulic fracturing) within a PDWSA or within five kilometres of a PDWSA bore or Aboriginal community bore, DMP will give DoW access to the EP and seek the

¹³⁶ Hon Simon O'Brien, Chairman and Mr Tadas Bagdon, Executive Director Policy and Innovation, Department of Water, *Transcript of Evidence*, 7 February 2014, p 2.

¹³⁷ Submission 115 from Department of Water, 15 October 2013, p 12.

¹³⁸ Department of Water and Department of Mines and Petroleum, *Administrative Agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in Western Australia*, 5 August 2015, p 2.

¹³⁹ *Ibid*, p 2.

department's advice before approving that EP.¹⁴⁰ Where petroleum activities are proposed outside a PDWSA, DMP will give DoW access to the EP, but the onus is on DoW to provide advice or comment to DMP; the EP approval process will not be suspended unless DoW requests this.

4.94 Other key points addressed in the agreement include that:

- DoW and DMP will share information where a petroleum operator notifies DMP of a water discovery during activities.
- DMP will advise DoW where it receives notification of any reportable incident that occurs within a PDWSA.
- DMP and DoW will continue to develop policies and procedures in relation to water resources and onshore petroleum activities.

Finding 12: The Committee finds that, whilst the agreement between the Department of Water and the Department of Mines and Petroleum is primarily administrative in its content, it is a positive development in the interagency regulation of the unconventional gas industry in Western Australia.

Compatibility of hydraulic fracturing activities with groundwater sources

4.95 DoW's 'Land Use Compatibility Table' (LUCT) is a key land use planning instrument for PDWSA. DoW submitted that the LUCT provides a 'whole of government approach' and is reflected in DoW's Water Quality Protection Note 25: 'Land use compatibility in Public Drinking Water Source Areas.'¹⁴¹ The LUCT is attached to this report at **Appendix 9**.

4.96 There are different classifications of PDWSA in Western Australia, as defined in DoW's policies.¹⁴² The different classifications are:

- Priority 1 areas (**P1**): the highest level of protection for a water source in the State. The guiding principle is risk avoidance. P1 areas normally encompass land owned or managed by State agencies, but may include private land that is

¹⁴⁰ The agreement provides that DMP will not approve the EP until DoW advice is received, or until more than 20 calendar days have elapsed since DoW was given access to the EP and DoW has not provided any advice: Department of Water and Department of Mines and Petroleum, *Administrative Agreement between the Department of Mines and Petroleum and Department of Water for onshore petroleum and geothermal activities in Western Australia*, 5 August 2015, p 4.

¹⁴¹ Submission 115 from Department of Water, 15 October 2013, p 8.

¹⁴² Including the *Public Drinking Water Resource Policy: Protecting Public Drinking Water Source Areas in Western Australia*, September 2005, Department of Water, *Water Quality Protection Note: Land use compatibility in Public Drinking Water Source Areas*, July 2004 and Department of Planning, *State Planning Policy 2.7: Public Drinking Water Source*, June 2003.

strategically significant to the protection of the drinking water source (for example, land immediately adjacent to a reservoir). Most land uses create some risk to water quality and are therefore defined as ‘Incompatible’ in P1 areas.

- Priority 2 areas (**P2**): are managed to ensure that there is no increased risk of water source contamination or pollution. For P2 areas, the guiding principle is risk minimisation. These areas include established low-risk land development (for example, low intensity rural activity). Some development is allowed within P2 areas for land uses that are defined as either ‘Compatible with conditions’ or ‘Acceptable.’
- Priority 3 areas (**P3**): are defined to manage the risk of pollution to the water source from catchment activities. Protection of P3 areas is mainly achieved through guided or regulated environmental (risk) management for land use activities. P3 areas are declared over land where water supply sources co-exist with other land uses such as residential, commercial and light industrial development. Land uses considered to have significant pollution potential are nonetheless opposed or constrained.¹⁴³

4.97 The LUCT lists the following activities, which may be associated with hydraulic fracturing, as incompatible within a PDWSA:

1. Wastewater infrastructure, that includes;

- *Treatment plants,*
- *Wastewater disposal to land, and*
- *Wastewater injection into the ground.*

2. Storage;

- *Chemical storage in underground tanks,*
- *Chemical storage in above ground tanks.*

3. Industry;

- *Chemical formulation.*¹⁴⁴

¹⁴³ There is a fourth category of protected areas: ‘Wellhead and reservoir protection zones’, which are specific zones defined to protect drinking water sources from contamination in the immediate vicinity of water extraction facilities.

¹⁴⁴ Submission 115 from Department of Water, 15 October 2013, p 8.

- 4.98 DoW will ‘generally oppose approval of such land use proposals...or any land use(s) that reflect the above activities in PDWSAs.’¹⁴⁵

1.5 kilometre buffer distance from Public Drinking Water Source Areas

- 4.99 The Water Corporation submitted that a key concept amongst a ‘number of agencies’ is the idea of a 1.5 kilometre buffer distance beyond PDWSA boundaries:

*The Department of Water (DoW) considers land uses or activities associated with unconventional gas exploration and production to represent an unacceptable risk within PDWSA. Therefore DoW states that unconventional gas activities should not occur within PDWSA surface boundaries. As there is the possibility of underground intrusion, DoW proposes an additional buffer distance of 1.5 km beyond the PDWSA boundary.*¹⁴⁶

- 4.100 The Committee examined this statement at a hearing:

Hon Stephen DAWSON: *Just on that issue, I just want to clarify, the submission does say that it is DOW who are proposing an additional buffer distance of 1.5 kilometres. So, it is not Water Corp arbitrarily saying this; it is actually DOW who are saying this and you agree with them. Is that correct?*

Mr Vincent: *Yes. The notion of putting buffers around protection areas is recognised amongst a number of agencies.*¹⁴⁷

- 4.101 The Committee sought clarification from the Minister for Water regarding the issue of the 1.5 kilometre buffer distance. The Acting Minister for Water advised the Committee that DoW’s actual position is that:

*the risks to water resources can be avoided, minimised or managed through case-by-case project assessments and management options to suit the local hydrogeological conditions of each project, rather than the adoption of a consistent buffer distance in addition to a PDWSA for all unconventional gas activities.*¹⁴⁸

- 4.102 The Committee notes that, regardless of the issue of a 1.5 kilometre buffer being necessary, the recent administrative agreement entered into by DMP and DoW (see

¹⁴⁵ Submission 115 from Department of Water, 15 October 2013, p 8.

¹⁴⁶ Submission 47 from Water Corporation, 20 September 2013, p 5.

¹⁴⁷ Hon Stephen Dawson, Deputy Chair and Mr Ashley Vincent, General Manager Planning and Capability Group, Water Corporation, *Transcript of Evidence*, 10 February 2014, p 8.

¹⁴⁸ Letter from Hon Terry Redman MLA, Acting Minister for Water, 17 June 2015, p 2.

paragraph 4.91) gives DoW access to the relevant EP for any proposed petroleum activities which may occur within five kilometres of a PDWSA bore or Aboriginal community bore, or within a PDWSA. These new administrative arrangements will ensure the continued protection of PDWSA in Western Australia to the highest level and that DoW is in the best position to ‘avoid, minimise or manage’ any risks to the State’s water supplies.

Finding 13: The Committee finds that there are sufficient safeguards and water source protection policies in place to protect Public Drinking Water Source Areas in Western Australia without the introduction of a 1.5 kilometre buffer zone between water source areas and unconventional gas activity.

Finding 14: The Committee finds that the Department of Water is acutely aware of the importance of protecting Public Drinking Water Source Areas and their integrity in Western Australia and is addressing this issue proactively through measures such as the new administrative agreement with the Department of Mines and Petroleum.

4.103 The Water Corporation’s view is that it is not as involved in the regulation of hydraulic fracturing activities as it is not seen as a key stakeholder. The Water Corporation believes that it should be involved, in order to protect public drinking water sources:

[Establishing the necessary safeguards to protect public drinking water]...has been further hindered by the inability to obtain regular and valued communication with the regulator of unconventional gas extraction, the Department of Mines and Petroleum. It is unfortunate that Water Corporation is not seen as a key stakeholder even though we are also responsible for the sustainable “mining” of groundwater.¹⁴⁹

4.104 The Committee explored the Water Corporation’s role further at a hearing:

***Hon Stephen DAWSON:** On that issue, Mr Vincent, in your submission you talk about DMP convening an interagency working group that develops policies and frameworks governing fracking. I was surprised to read that the Water Corporation is not involved or on that interagency working group. Is there any reason why?*

***Mr Vincent:** It is probably not my place to speculate why. There is none that I am aware of.*

¹⁴⁹

Submission 47 from Water Corporation, 20 September 2013, p 2.

Hon Stephen DAWSON: *So have DMP ever given you a reason why Water Corporation is not?*

Mr Vincent: *No, we have not.*

Hon Stephen DAWSON: *It would make perfect sense to me.*

Mr Vincent: *Yes, absolutely. I think we have expertise and knowledge that we can lend to the discussion. We have experience and direct involvement in the management catchments and proclaimed areas that we think can add value to the discussion. I think that the interagency committee recognises the formal regulatory players and the regulatory approvals that need to be made within the state. We do not have a place in that necessarily, but we do have a role as protectors of catchments, if you like, once areas are proclaimed.¹⁵⁰*

- 4.105 The Committee is concerned that the Water Corporation has no involvement in the inter-agency committee on shale and tight gas. The Water Corporation plays an important role in ensuring the public water supply is safe and not adversely affected by hydraulic fracturing.

Recommendation 4: The Committee recommends that the Department of Mines and Petroleum develop a mechanism to consult with the Water Corporation (or, in the case of regional areas, with the relevant water provider) in relation to the regulation of hydraulic fracturing activities.

Department of Health

- 4.106 The Department of Health's (DoH) involvement in regulating the onshore gas industry is 'mainly reactive' and 'quite limited.'¹⁵¹ The *Health Act 1911* provides the Executive Director, Public Health with the power to make inquiries¹⁵² and act in an 'emergency or necessity.'¹⁵³
- 4.107 The Executive Director Public Health described the effect of the 'reactive'¹⁵⁴ powers of DoH under the *Health Act 1911* as follows:

¹⁵⁰ Hon Stephen Dawson, Deputy Chair and Mr Ashley Vincent, General Manager Planning and Capability Group, Water Corporation, *Transcript of Evidence*, 10 February 2014, pp 4-5.

¹⁵¹ Professor Tarun Weeramanthri, Executive Director Public Health, Department of Health, *Transcript of Evidence*, 17 February 2014, p 1.

¹⁵² *Health Act 1911* s 13.

¹⁵³ *Ibid*, s 15.

¹⁵⁴ Professor Tarun Weeramanthri, Executive Director Public Health, Department of Health, *Transcript of Evidence*, 17 February 2014, p 1.

This means that, at times, in dealing with contentious public issues, DOH input has not been sought until the end of the process, or when a crisis develops. As a result, DOH are often trying to interpret existing situations rather than proactively informing best practice to avoid or manage risks to Public Health.

Better results have been achieved where DOH has been consulted from the start.¹⁵⁵

- 4.108 Whilst DoH has no formal role in the approval process for petroleum drilling licences or onshore drilling fields, it is 'in continuing communication with DMP' and is involved in DMP's inter-agency committee. DoH submitted the following strategic recommendations relating to the interaction between DMP and DoH to improve relations:

Strategic Recommendations

1. A Memorandum of Understanding (MOU) between DMP and DOH should be put in place to review chemical risks assessment for petroleum programs drilling, including hydraulic fracturing for unconventional gas. The MOU should include details of:

- a. an initial assessment scoping process to provide for an early decision as to whether there are likely to be any Public Health risk and whether they should be assessed and by whom; and*
- b. early alert conditions for referral of proposals to DOH.*

2. The DMP approvals framework should acknowledge and include the role of DOH including details:

- a. as to whether and when proposals are referred to DOH for advice;*
- b. approvals transparently showing how DOH advice was used;*
- c. ensuring that, where risks to Public Health do exist, appropriate measures are put in place to deal with them according to DOH guidelines;*

¹⁵⁵

Submission 107 from Department of Health, 4 October 2013, p 1.

d. of DMP commitments to audit the proponent's compliance with DOH guidelines and report on any non-compliances, impacting on Public Health, to DOH in a timely manner.

3. Proponents should be required to prepare and implement an open and transparent risk communication strategy.

4. All decisions relating to hydraulic fracturing should be transparent with all decision-making being properly supported with scientific evidence and in accordance with the Precautionary Principle.

5. If onshore unconventional oil and gas wells are not defined as "mining operations" under the Mine Operations Regulations 16, then the regulation of radioactive substances will fall under the jurisdiction of the Radiological Council.¹⁵⁶

4.109 DoH advised the Committee that the Memorandum of Understanding between it and DMP has not yet been agreed to and that DoH is 'not rushing to do this tomorrow or next week' and progress has not yet been made.¹⁵⁷ DoH's involvement in the unconventional gas regulatory framework is not classified by DMP as part of the 'key regulatory processes' that complement DMP's role in regulating hydraulic fracturing in Western Australia (see paragraph 4.54).

Human Health Risk Assessment

4.110 DoH provided the final version of its Human Health Risk Assessment, 'Hydraulic fracturing for shale and tight gas in Western Australian drinking water supply areas' (HHRA) in June 2015. The HHRA focuses on the 'risk of drinking water supply contamination from the result of hydraulic fracturing processes, particularly from well drilling, hydraulic fracturing fluid and flowback of fluid in wells.'¹⁵⁸

4.111 The HHRA emphasises the need to consider public health issues (where relevant) in the approvals process for hydraulic fracturing and found that:

under the right conditions, hydraulic fracturing of shale gas reserves in WA can be successfully undertaken without compromising drinking water sources...

the risks to drinking water sources associated with hydraulic fracturing can be well managed through agreed industry and

¹⁵⁶ Submission 107 from Department of Health, 4 October 2013, pp 5-6.

¹⁵⁷ Professor Tarun Weeramanthri, Executive Director Public Health, Department of Health, *Transcript of Evidence*, 17 February 2014, p 3.

¹⁵⁸ Department of Health, *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supply areas: Human Health Risk Assessment*, June 2015, p 20.

*engineering standards, best practice regulation, appropriate site selection (including consideration of Public Drinking Water Source Areas) and monitoring of the drinking water source.*¹⁵⁹

4.112 DoH included the following recommendations as part of the HHRA:

- that the Australian Drinking Water Guidelines, which are drafted by the National Health and Medical Research Council, be applied for chemicals found in drinking water, or that more detailed human health risks assessments be conducted where no regulatory guidelines have been established
- that a communication plan for the notification of incidents that have the potential to impact public health and drinking water sources be incorporated into ongoing stakeholder engagement
- ongoing consultation and collaboration between all government agencies with responsibilities related to the potential impacts of hydraulic fracturing
- that the HHRA be used as part of the State's regulatory framework for hydraulic fracturing¹⁶⁰

4.113 DoH submits that baseline monitoring and data collection is essential to effectively protect Western Australia's drinking water supplies:

*In order to confirm that origin of contamination and to ensure protection of sensitive water supplies, it is pertinent to ensure that baseline characterisation is well designed and there is ongoing appropriate surveillance in the vicinity of sensitive receptors such as those near drinking water abstraction wells.*¹⁶¹

4.114 The DoH's view is that the precautionary approach must be balanced against undertaking background and ongoing surveillance monitoring, so that significant risks and potential impacts can be minimised, if not eliminated completely.¹⁶² An 'accurate and transparent public record' of chemicals that are used in hydraulic fracturing is important, as is research into the aquifer systems throughout Western Australia to build a 'cumulative dataset.'

4.115 The HHRA contains a 'Human Health Risk Assessment Framework', which focuses on the potential adverse health effects related to drinking water contamination. The

¹⁵⁹ Department of Health, *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supply areas: Human Health Risk Assessment*, June 2015, p 1.

¹⁶⁰ Ibid, pp 1-2.

¹⁶¹ Ibid, p 25.

¹⁶² Ibid, p 35.

framework illustrates general steps to follow in order to identify and manage the risks associated with a human health impact. These include:

- issue identification
- hazard assessment
- exposure assessment
- risk characterisation
- risk management.¹⁶³

4.116 As part of the HHRA's hazard assessment, DoH identified 195 'substances of concern' (chemicals), based on international data. The HHRA further categorises the 195 substances into four groups, depending on the stage of hydraulic fracturing at which they occur:¹⁶⁴

- Substances used in the drilling process: 22 substances are included in this category; three are listed as known carcinogens.
- Substances used as additives to hydraulic fracturing fluid but not detected in flowback fluid: 47 substances are included in this category; three are listed as known or suspected carcinogens (ethanol is discussed separately).
- Substances used as additives to hydraulic fracturing fluid and detected in flowback fluid: 35 substances are listed in this category; six are listed as suspected carcinogens.
- Substances that were not used as additives in hydraulic fracturing fluid but were detected in flowback fluid: 96 substances are listed in this category; 28 are listed as known or suspected carcinogens.

4.117 The HHRA acknowledges that the exposure risk from contamination to drinking water depends on local environmental conditions and geology and the specifics of the water supply itself. The concentration of a chemical is also central in determining any human toxicity effects:

Several potentially toxic chemicals have been identified within hydraulic fracturing fluids and flowback fluids and produced waters. However it is important to acknowledge that human toxicity is dependent on the concentration taken into the body, or dose. If the

¹⁶³ Department of Health, *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supply areas: Human Health Risk Assessment*, June 2015, p 19.

¹⁶⁴ *Ibid*, pp 22-24 and Tables 1 through 7.

*potentially toxic chemicals are present in hydraulic fracture fluids or in drinking water supplies and a concentration below an identified threshold of toxicological concern (TTC) it is unlikely that this exposure will lead to any aesthetic or health impact.*¹⁶⁵

4.118 Risk will also depend upon:

*failure to follow industry best practice design, construction, maintenance and closure...*¹⁶⁶

4.119 The Committee is of the view that the HHRA will become a valuable document in the regulation of hydraulic fracturing in Western Australia.

Finding 15: The Committee finds that the Department of Health's *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supply areas: Human Health Risk Assessment* is an important document in informing the public debate about hydraulic fracturing.

COMMONWEALTH INVOLVEMENT

4.120 The onshore minerals industry is largely regulated at the State level, but the Commonwealth has a role pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

4.121 The Commonwealth Department of Health administers the statutory scheme: National Industrial Chemical Notification Assessment Scheme (NICNAS), which assessed industrial chemicals.¹⁶⁷ Under NICNAS, the Commonwealth Department of Health:

- assesses new industrial chemicals for human health and/or environmental impacts before they enter Australia
- maintains the Australian Inventory of Chemical Substances
- reviews existing industrial chemicals of concern
- provides information on the impacts of industrial chemicals and making recommendations on their safe use
- registers introducers/importers of industrial chemicals.¹⁶⁸

¹⁶⁵ Department of Health, *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supply areas: Human Health Risk Assessment*, June 2015, p 40.

¹⁶⁶ Ibid, p 35.

¹⁶⁷ National Industrial Chemical Notification Assessment Scheme. Available at: <http://www.nicnas.gov.au/about-nicnas/about-us>. Viewed 24 April 2015.

- 4.122 Under NICNAS, a national assessment of chemicals associated with CSG extraction in Australia is currently being undertaken, which includes an examination of the human health and environmental risks from chemicals used in hydraulic fracturing for CSG. This National CSG Chemicals Assessment (**National Assessment**) is a collaboration between NICNAS and the CSIRO, the Commonwealth Department of Environment and Geoscience Australia.¹⁶⁹
- 4.123 The National Assessment will identify chemicals used in drilling and hydraulic fracturing for CSG and provide information on the risks and effects of those chemicals on human health and the environment. The project is scheduled to be completed in 2015.

OTHER AUSTRALIAN JURISDICTIONS

- 4.124 An understanding of other Australian jurisdictions' experiences with the hydraulic fracturing industry and its regulation helps inform debate on the industry in Western Australia.

New South Wales

- 4.125 New South Wales has an established unconventional gas industry, centred around its significant CSG reserves (mostly in the Gunnedah, Gloucester and Sydney Basins¹⁷⁰).
- 4.126 The New South Wales Legislative Council General Purpose Standing Committee No. 5 examined the impacts of CSG activities in that State, including environmental impacts and landholder rights.¹⁷¹ The committee made 35 recommendations to the New South Wales Government, including recommending that no further production licences for CSG be issued until a comprehensive framework for the regulation of the CSG industry is implemented: that is, that there be a moratorium on issuing licences.¹⁷² The New South Wales Government did not support this recommendation.¹⁷³

¹⁶⁸ National Industrial Chemical Notification Assessment Scheme. Available at: <http://www.nicnas.gov.au/about-nicnas/about-us>. Viewed 24 April 2015.

¹⁶⁹ National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia. Available at: <http://www.nicnas.gov.au/communications/issues/fracking-hydraulic-fracturing-coal-seam-gas-extraction/information-sheet>. Viewed 24 April 2015.

¹⁷⁰ New South Wales, Department of Trade and Investment, Division of Resources and Energy, *Coal Seam Gas Fact Sheet 1: What is Coal Seam Gas?*, March 2013.

¹⁷¹ New South Wales, Legislative Council, General Purposes Standing Committee No. 5, Report 35, *Coal Seam Gas*, 1 May 2012.

¹⁷² New South Wales, Legislative Council, General Purposes Standing Committee No. 5, Report 35, *Coal Seam Gas*, 1 May 2012, p 223.

¹⁷³ New South Wales, Legislative Council, *Legislative Council General Purpose Standing Committee No. 5 Inquiry into Coal Seam Gas: NSW Government Response October 2012*, Tabled Paper 2241, 13 November 2012, p 15.

4.127 A 2014 report by Professor Mary O’Kane, the NSW Chief Scientist and Engineer found that many of the technical challenges and risks posed by the CSG industry can, in general, be managed through careful planning, high industry standards and comprehensive monitoring with ongoing scrutiny of data.¹⁷⁴ The Chief Scientist’s inquiry also found that there are key issues of concern in the community in relation to CSG, including:

- land rights and support for landowners
- impact on water sources and possible contamination
- lack of ‘adequate and respectful’ consultation
- complex and ‘opaque’ legislation and regulatory processes
- lack of trust of companies.¹⁷⁵

4.128 These concerns mirror those of the Western Australian community.

Victoria

4.129 The unconventional gas industry in Victoria is at a very early stage, with no confirmed resources of either CSG or shale gas.¹⁷⁶ Most of Victoria’s gas is produced from its conventional offshore gas resources (second in production quantities to Western Australia). Whilst there is potential for tight gas to be exploited in the Gippsland and Otway Basins, the feasibility of its extraction is still unknown.

4.130 On 24 August 2012, the Victorian Government announced a hold on both further approvals to undertake hydraulic fracturing as part of onshore gas exploration and on new exploration licences.¹⁷⁷

4.131 In late 2013, the Government released the Reith Gas Market Taskforce Report for public consultation. Then Premier Hon Denis Napthine stated that the report was the first step in the Government’s decision making process. The Government then announced in 2013 that ‘the moratorium on hydraulic fracturing will remain in place until at least July 2015 while the community consultation process is conducted.’¹⁷⁸

¹⁷⁴ New South Wales, NSW Chief Scientist & Engineer, *Final Report of the Independent Review of Coal Seam Gas Activities in NSW*, September 2014.

¹⁷⁵ Ibid, pp 7-8.

¹⁷⁶ Victoria, Parliamentary Library Research Service, *Research Paper Unconventional Gas: Coal Seam Gas, Shale Gas and Tight Gas*, Dr C Ross & P Darby, December 2013, p 11-12.

¹⁷⁷ Victoria, Minister for Energy and Resources, Media Release, *Reforms to Strengthen Victoria’s Coal Seam Gas Regulation and Protect Communities*, 24 August 2012.

¹⁷⁸ Victoria, Premier, Media Release, *Gas Market Taskforce Paper Open for Public Consultation*, 21 November 2013.

4.132 On 26 May 2015, Victoria's Legislative Council referred an inquiry to the Environment and Planning Committee into 'matters relating to the exploration, extraction, production and rehabilitation for onshore unconventional gas.' The inquiry's terms of reference focus on:

- the potential benefits of onshore unconventional gas as an energy source
- the potential risks, including risks to the environment, land productivity, agricultural industries and public health, and whether such risks can be managed
- the impact on the legal rights of property owners and existing land and water uses
- how this issue is managed in other Australian and international jurisdictions
- potential changes to Victoria's legislative and regulatory framework.¹⁷⁹

4.133 The committee presented its interim report on 1 September 2015, with a final report due to the Victorian Parliament on 1 December 2015.

Queensland

4.134 Queensland has the most established unconventional gas industry in Australia, having been a producer of CSG since the early 1990s. CSG is currently the major domestic gas fuel source in Queensland and provides about 90 per cent of the State's domestic gas supply.¹⁸⁰ Commercial production of Queensland's CSG is currently only sourced from the Bowen and Surat Basins.

4.135 Queensland is also where a large proportion of media attention related to protest groups and anti-hydraulic fracturing activism is focused. The towns of Chinchilla and Tara, the Condamine River and the Lock the Gate Alliance are frequently associated with CSG protests.

4.136 The CSG Compliance Unit of Queensland's Department of Natural Resources and Mines regulates and monitors the CSG industry. The Queensland Government also established the GasFields Commission (GFC) as an independent statutory body under the *Gasfields Commission Act 2013* (Qld) to 'manage and improve the sustainable

¹⁷⁹ Victoria, Legislative Council, Standing Committee on the Environment and Planning, *Media Release*, 9 June 2015.

¹⁸⁰ Queensland, Department of Natural Resources and Mines, *Queensland's petroleum and coal seam gas 2013-14*, p 1.

coexistence of landowners, regional communities and the onshore gas industry in Queensland.’¹⁸¹

- 4.137 The Committee’s discussions with the Commissioner of the GFC, Mr John Cotter, relating to the GFC and Queensland’s *Land Access Code* (which sets out guidelines for communication between operators and landholders) are canvassed in CHAPTER 5.

South Australia

- 4.138 The South Australian unconventional gas industry is also one of the most developed in Australia. South Australia has several significant shale gas deposits, mostly notably the Cooper Basin in the State’s northeast. Moomba in the Cooper Basin has a long history of hydraulic fracturing: hydraulic fracturing has been occurring there for almost 50 years.¹⁸²

- 4.139 The Parliament of South Australia, House of Assembly Natural Resources Committee is currently inquiring into the potential risks and impacts of the use of hydraulic fracturing in the southeast of South Australia, with broadly similar terms of reference to this inquiry.¹⁸³

- 4.140 The original motion for the South Australian inquiry referred to the impacts of hydraulic fracturing across the entire State, but this was amended to focus only on south-eastern South Australia, thus removing the Cooper Basin from the inquiry. The Natural Resources Committee plans to table an interim report by the end of 2015, with its final report and recommendations due in mid-2016.¹⁸⁴

¹⁸¹ *Gasfields Commission Act 2013* (Qld), s 3.

¹⁸² South Australia, Department of State Development, *Frequently Asked Questions*, July 2014. Available at: http://petroleum.dmitre.sa.gov.au/prospectivity/basin_and_province_information/unconventional_gas/frequently_asked_questions. Viewed 23 April 2015.

¹⁸³ The Committee’s terms of reference include to investigate ‘the risks of groundwater contamination; the impacts upon landscape; the effectiveness of existing legislation and regulation; and the potential net economic outcomes to the region and the rest of the state’: South Australia, Legislative Council, *Parliamentary Debates (Hansard)*, 19 November 2014, pp 1718-1725.

¹⁸⁴ South Australia, House of Assembly, Natural Resources Committee, *Update: Inquiry into Unconventional Gas (Fracking) in the South East of South Australia*, 11 September 2015.



Figure 12. Cattle grazing on land at Santos operations with drilling rig in background at Cooper Basin, South Australia [Source: Committee site visit, 3 September 2014]

Tasmania

- 4.141 Tasmania does not have any confirmed unconventional gas deposits. No hydraulic fracturing has been undertaken in the State.
- 4.142 Nonetheless, in 2014 the Tasmanian Government imposed a 12 month moratorium on hydraulic fracturing to enable its Department of Primary Industries, Parks, Water and Environment to facilitate a review of the technology, its potential impacts on the environment and the robustness of Tasmania's regulatory regime.¹⁸⁵
- 4.143 The review was conducted in collaboration with the Environment Protection Authority Division and with Mineral Resources Tasmania in the Department of State Growth. The review report contained 17 key findings.¹⁸⁶
- 4.144 On 26 February 2015, the Tasmanian Government extended its moratorium on hydraulic fracturing for a further five years until March 2020 in order to consult

¹⁸⁵ The full terms of reference for the 'Review of Hydraulic Fracturing in Tasmania Project' are available at: <http://dpiwwe.tas.gov.au/Documents/TOR%20Review%20of%20fracking%20in%20Tasmania.pdf>. Viewed 27 February 2015.

¹⁸⁶ Tasmania, Department of Primary Industries, Parks, Water and Environment, *Review of hydraulic fracturing in Tasmania: Final Report*, 25 February 2015.

with stakeholders, monitor national and international science and policy developments and conduct a further Executive review of hydraulic fracturing.¹⁸⁷

Northern Territory

- 4.145 There are several onshore unconventional gas basins either wholly or partly contained within the Northern Territory, including the Beetaloo, Amadeus and Pedirka Basins.¹⁸⁸ Whilst these are not significant in potential compared to Western Australia's unconventional gas reserves, hydraulic fracturing activity is scheduled for the Territory, with up to 24 wells approved for drilling in 2015.¹⁸⁹
- 4.146 In 2014, the Northern Territory Government commissioned Mr Allan Hawke AC to conduct an independent inquiry into hydraulic fracturing in the Territory to investigate the process and its potential effects on the environment.¹⁹⁰
- 4.147 The Commissioner made six recommendations to the Northern Territory Government, including that 'there is no justification whatsoever for the imposition of a moratorium on hydraulic fracturing in the NT' and that:

*the environmental risks associated with hydraulic fracturing can be managed effectively subject to the creation of a robust regulatory regime.*¹⁹¹

¹⁸⁷ Refer to Tasmania, Premier, Minister for Primary Industries and Water, Media Release, *Fracking Moratorium to Continue*, 26 February 2015. See also Tasmanian Government, Policy Statement on Hydraulic Fracturing (Fracking) 2015, February 2015. Available at: http://dpipwe.tas.gov.au/Documents/Tasmanian%20Fracking%20Policy%20Statement_26-2-15.pdf. Viewed 23 April 2015.

¹⁸⁸ ACOLA Report, pp 48-49.

¹⁸⁹ Northern Territory Government, Fact Sheet, *Onshore Natural Gas in the Northern Territory*, p 1.

¹⁹⁰ *Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory*, Tabled Paper 1257. Also available at: <http://www.hydraulicfracturinginquiry.nt.gov.au/index.html>.

¹⁹¹ *Ibid*, p x.

CHAPTER 5

ACCESS TO LAND AND LAND USE

For many landholders, despite understanding that they do not own the mineral resources under their land, the realisation that they are legally required to give access to their land to gas exploration companies and that those companies could, for example, construct roads, clear drilling sites, build work camps and, ultimately, construct gas production facilities, came as a profound shock.

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*¹⁹²

5.1 This inquiry has generated a great deal of community interest and debate about the potential impact of hydraulic fracturing on land use. Residents of Western Australia are concerned about the impact of shale gas exploration on existing agricultural land, native title holders and from the footprint of exploration companies.

5.2 The issue of negotiating land rights between landowners or leaseholders and exploration companies is a multi-layered and complicated issue, requiring a balance of competing rights. This chapter will focus on how the legislative regime in Western Australia deals with the right to access land for the purposes of unconventional gas development and the infrastructure footprint of the industry.

5.3 ACOLA found that:

*Australian rangeland landscapes that contain prospective shale gas resources coincide with vast and remote parts of Australia's inland that support contiguous and extensive areas of arid and semi-arid vegetation and are managed by pastoralists and indigenous people.*¹⁹³

5.4 Other common characteristics of these landscapes include:

- low average but highly variable annual rainfall, sporadic flooding and scarce 'permanent' water sources
- a rich range of native plants and animals
- significant feral animal and plant populations

¹⁹² 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, p 53.

¹⁹³ ACOLA Report, p 99.

- cattle grazing (or sheep grazing to a lesser extent) as the main land use.¹⁹⁴
- 5.5 These are general characteristics only. The Committee notes that the land above the Perth Basin differs in its higher average rainfall, higher population and agricultural development and high levels of biodiversity (especially when compared to the Canning Basin).
- 5.6 The additional land use proposed by unconventional gas development is nonetheless significant in Western Australia and an important issue for consideration.
- 5.7 The Committee notes that there is much greater potential for conflict in land use in the Perth Basin, due to the close proximity of townships and prime agricultural land to onshore gas deposits.

RIGHT TO ACCESS LAND UNDER PGERA

- 5.8 The Committee introduced the legislative regime governing mineral rights in Western Australia at paragraphs 4.2 to 4.6. The interaction between property rights and mining legislation is a complex area of law. This chapter explores the potential conflict between land access legislation and social responsibility and will comment on the issue of social licence (see CHAPTER 10) and its implications for hydraulic fracturing in Western Australia.
- 5.9 Part II of the PGERA contains provisions dealing with access to ‘private land’ for the purposes of exploring for petroleum or geothermal energy resources (which includes hydraulic fracturing). ‘Private land’ is defined in section 5 of the PGERA as:

any land which has been or may hereafter be alienated from the Crown for any estate of freehold, or is or may hereafter be the subject of any conditional purchase agreement, or of any lease or concession with or without the right of acquiring the fee simple thereof, other than –

(a) a pastoral lease within the meaning of the Land Administration Act 1997, or a lease otherwise granted for grazing purposes only; or

(b) a lease for timber purposes; or

(c) a lease for the use and benefit of the Aboriginal inhabitants.

- 5.10 PGERA provides that:

¹⁹⁴ ACOLA Report, pp 99-100.

- A petroleum company cannot access private land until compensation is paid or agreed: section 20(1).
- A private land holder does not have a right of refusal for access to their land by a petroleum title holder except where:
 1. the freehold title is less than 2000 square metres in area: section 16(1a)(a); or
 2. the land is used as a cemetery or burial place: section 16(1a)(b); or
 3. the land is within 150 metres of a cemetery or burial place, substantial improvement, or reservoir. Section 16(2)(a) defines ‘reservoir’ to include any natural or artificial storage or accumulation of water, spring, dam, bore and artesian well. The Minister is the sole judge of whether any improvement is substantial: section 16(2)(b) and there is no statutory definition or other DMP policy that explains what constitutes a ‘substantial improvement.’¹⁹⁵
- Owners of private land in the vicinity affected by activity may be entitled to compensation: section 18.
- If land access and compensation cannot be agreed to, the land holder and the petroleum title holder may refer those matters to a Magistrates Court for decision: section 17(4).

5.11 A petroleum company still has a right to access leased land to conduct petroleum activities. Section 21 of PGERA provides for a petroleum company to pay compensation for any damage caused to ‘any improvements’ on leased land (leased by way of a pastoral or timber lease or a lease for the use and benefit of the Aboriginal inhabitants). Sections 21(2) and (3) of the PGERA respectively set out that the compensation may be paid by agreement or by application to the Magistrates Court.

5.12 The Committee observes that the rights of lease holders to compensation for damage to their land are therefore similar to those of private land owners, but are limited to compensation for ‘damage caused to any improvements on land’ only. Section 24 of the PGERA specifies several matters for which lease holders are not normally entitled to compensation,¹⁹⁶ including:

¹⁹⁵ Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 15.

¹⁹⁶ Section 24(1) begins with the words: ‘Except where and then only to the extent agreed to by the parties or authorised by the Court’ in relation to compensation that is payable.

- deprivation of the possession of the surface of the land or any part of the surface
- damage to the surface of the land
- where the affected lessee is deprived of the possession of the surface of any land, for severance of the land from any other land of the affected lessee
- for surface rights of way or easements.

MULTIPLE LAND USE FRAMEWORK

5.13 In 2013, the Council of Australian Governments Energy Council (**Energy Council**) developed a policy document to address the challenges arising from competing land use, land access and land use changes in the minerals and energy resources sector.¹⁹⁷ The Energy Council is comprised of Commonwealth, State, Territory and New Zealand government ministers with responsibility in their jurisdiction for energy and resource matters.

5.14 The Energy Council developed the Multiple Land Use Framework (**MLUF**) to address the challenges arising from competing land use, land access and land use changes in the minerals and energy resources sector. MLUF's objective is to 'enable government, community and industry to effectively and efficiently meet land access and use challenges, expectations and opportunities.'¹⁹⁸ MLUF is designed to operate within established regulatory and policy frameworks relating to land ownership, usage and access. MLUF states 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.*¹⁹⁹

5.15 Multiple land use is defined in the MLUF as being where land is used for different purposes simultaneously and sustainably, with the objective of retaining options for current and future land use. MLUF includes the following 'Guiding Principles', intended to 'be embodied into the mindset of governments, community and industry in land use planning, policy and development':

- Best use of resources.
- Coexistence.

¹⁹⁷ COAG Energy Council. Available at: <http://www.scer.gov.au/about-us/>. Viewed 7 May 2015.

¹⁹⁸ Standing Council on Energy and Resources, *Multiple Land Use Framework*, 13 December 2013, p 1.

¹⁹⁹ Ibid, p 6.

- Strategic planning.
- Tailored participation of communities and landholders.
- Engagement and information.
- Decision making and accountability.
- Efficient processes.
- Accessible relevant information.²⁰⁰

5.16 A common theme in the Guiding Principles is engagement and open communication with landholders and the community. Both DMP and the Australian Petroleum Production and Exploration Association Limited (**APPEA**) refer to and endorse the principles that underpin the MLUF.²⁰¹

APPEA CODE OF PRACTICE FOR HYDRAULIC FRACTURING

5.17 In 2011, APPEA developed a voluntary code of practice for the onshore unconventional gas industry.²⁰² The ‘Code of Practice for Hydraulic Fracturing’ (**the Code**) discusses land access (amongst other things) and is based on established operating principles and leading practices in other jurisdictions.

5.18 The Committee’s notes, however, that this document is industry-centric in its origins and focus:

***The CHAIRMAN:** Was there any consultation with non-industry stakeholders in the preparation of the code of practice?*

***Mr Ellis:** There was not.²⁰³*

5.19 The Code contains seven guidelines for industry, together with a list of the applicable American Petroleum Institute standards which are relevant to onshore gas and

²⁰⁰ Standing Council on Energy and Resources, *Multiple Land Use Framework*, 13 December 2013, p 6.

²⁰¹ Submission 105 from Department of Mines and Petroleum, 3 October 2013, p11; Submission 104 from Australian Petroleum Production and Exploration Association, 3 October 2013, Attachment 2.

²⁰² Australian Petroleum Production and Exploration Association, *Western Australia Onshore Gas: Code of Practice for Hydraulic Fracturing*, 31 December 2011.

²⁰³ Hon Simon O’Brien, Chairman and Mr Stedman Ellis, Chief Operating Officer, Western Region, Australian Petroleum Production and Exploration Association, *Transcript of Evidence*, 7 February 2014, p 3.

hydraulic fracturing. APPEA is also working to develop national codes of practice for the onshore gas industry.²⁰⁴

LAND ACCESS ROUNDTABLE

5.20 In October 2013, APPEA established a Land Access Roundtable (**Roundtable**) initially through agreement between WAFarmers, WA Pastoralists and Graziers Association and APPEA, with membership then being extended to include representatives from vegetablesWA, Latent Petroleum and APPEA staff.²⁰⁵ Hon Hendy Cowan AO is the Chair of the Roundtable.

5.21 The Roundtable operates informally as a forum to ‘promote understanding and coexistence of petroleum and farming activities’ and often calls on expert advice from stakeholders such as the CSIRO, DMP and from legal advisors.²⁰⁶ A key initiative developed by the Roundtable is the Farming Land Access Agreement and associated documents, which are currently being finalised by the Roundtable. The draft agreement includes specific guidance in relation to:

- payment of agreed reasonable costs relating to negotiation of a land access agreement
- compensation for impacts relating to the petroleum industry
- establishment of a mediation process to provide an avenue for resolving disputes without recourse to arbitration through the Magistrates Court
- the default provision that land access agreements are public documents unless agreed otherwise by the land holder and operator.²⁰⁷

Finding 16: The Committee finds that the Australian Petroleum Production and Exploration Association Limited’s Land Access Roundtable is a worthy initiative to bring land owners and resource companies to the negotiating table with regard to land access, but more needs to be done to ensure that land owners’ rights are protected.

²⁰⁴ Mr Stedman Ellis, Chief Operating Officer, Western Region, Australian Petroleum Production and Exploration Association, *Transcript of Evidence*, 7 February 2014, p 3.

²⁰⁵ Letter from Mr Stedman Ellis, Chief Operating Officer Western Region, APPEA, 10 June 2015, p 2.

²⁰⁶ Ibid, p 2-3.

²⁰⁷ Ibid, p 3.

LAND ACCESS IN OTHER JURISDICTIONS

- 5.22 The nascent nature of the onshore gas industry in Western Australia means that we are able to draw upon the experiences of other Australian States in terms of land access policies for hydraulic fracturing and land use agreements.
- 5.23 The relationship between industry and farmers in Western Australia has already begun to improve upon what it was in the past:

I think what has happened is some companies have said, "I only need to talk to this particular landowner, and he has to let me onto his property." I have seen that over the last 20-odd years in Western Australia. It is not good practice...

But what is happening, and we have seen it especially over the last three years in the Midwest and in the Kimberley, is that the companies are taking on that responsibility a lot better.²⁰⁸

- 5.24 The Committee has researched the relationship between industry and landholders in other Australian jurisdictions, as well as how land access for onshore gas is regulated internationally. Discussion will focus on Queensland and South Australia, as these States' unconventional gas industries are more developed than Western Australia's and can be used to inform decision-makers in Western Australia.

Queensland

- 5.25 Natural resources in Queensland, including gas that occurs deep underground such as shale gas or CSG, are owned by the State and managed by the Government for the benefit of residents, just as they are in Western Australia.²⁰⁹
- 5.26 Exploration for and production of CSG began to expand rapidly in south-eastern Queensland in the mid to late 2000s, accompanied by increasing concern from the agricultural sector about the impact of the industry on farming and land use.

Land Access Code and Framework

- 5.27 In May 2008, the then Government established the Land Access Working Group to facilitate communication, improve relations and 'develop a collaborative policy framework' between the CSG mining and agricultural sectors.²¹⁰

²⁰⁸ Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum, *Transcript of Evidence*, 12 September 2014, p 17.

²⁰⁹ *Petroleum and Gas (Production and Safety) Act 2004* (Qld), Chapter 2 'Petroleum tenures and related matters' ss 31-33.

²¹⁰ Queensland, Land Access Review Panel, *Land Access Framework – 12-month review: Report of the Land Access Review Panel*, February 2012, p 2.

5.28 Land Access Working Group membership included AgForce, the Queensland Farmers' Federation, APPEA, the Queensland Resources Council and the Association of Mining and Exploration Companies and the Department of Employment, Economic Development and Innovation. The Land Access Framework was the result of this collaboration. Key features of the framework include:

- the creation of the Land Access Code, a standard Conduct and Compensation Agreement and relevant fact sheets
- a requirement that all resource authority holders must comply with a single Land Access Code (see paragraph 5.29)
- an entry notice requirement for 'preliminary activities', that is, exploration activities that will have no or only a minor impact on landholders' land use and business
- a requirement that a Conduct and Compensation Agreement be negotiated before a resource authority holder comes onto a landholders' property to undertake 'advanced activities': that is, those that are likely to have a significant impact
- a graduated process for negotiating and resolving disputes about agreements that ensures matters are only referred to the Land Court as a last resort
- information sessions conducted for landholders and industry.²¹¹

5.29 The Land Access Code came into effect in 2010 pursuant to section 24A of the *Petroleum and Gas (Production and Safety) Act 2004* (Qld), which provides that:

*(1) A regulation may make a single code for all resource Acts (the **land access code**) that –*

(a) states best practice guidelines for communication between the holders of authorities and owners and occupiers of private land; and

(b) imposes on the authorities mandatory conditions concerning the conduct of authorised activities on private land.

5.30 The Land Access Code in its current form contains three parts.²¹² Part 2 ('Good Relations') sets out general principles for landholders and resource authority holders,

²¹¹ Queensland, Land Access Review Panel, *Land Access Framework – 12-month review: Report of the Land Access Review Panel*, February 2012, p 3.

guidelines for communication and negotiations. Part 3 ('Mandatory Conditions for Resources Authorities') details resource authority holders' obligations relating to:

- training their staff to understand the Land Access Code and relevant Acts
- the use and construction of access points, roads and tracks on landholder's land
- minimising impact on livestock and property
- preventing the spread of declared pests
- setting up and managing work camps
- items brought onto land (including items that are prohibited without consent, such as firearms, domestic animals and alcohol)
- the use of, and damage to, gates and fences.²¹³

5.31 These mandatory conditions contain an overriding theme of responsible industry and respect for the landholder's right to enjoy the land, despite the strict legal right that the resource authority holder can exploit underground resources.

5.32 The *Petroleum and Gas (Production and Safety) Act 2004* (Qld) sets out when a resource authority holder is liable to compensate a landholder, including factors relating to the land's value and access and:

*accounting, legal or valuation costs the claimant necessarily and reasonably incurs to negotiate or prepare a conduct and compensation agreement, other than the costs of a person facilitating an ADR [alternative dispute resolution process].*²¹⁴

Finding 17: The Committee finds that it is a fundamental expectation of the Australian community that a resource company must negotiate with a land owner before seeking to enter onto their land.

²¹² The Land Access Code consists of the best practice guidelines stated in Parts 1 and 2 of the 'Land Access Code' document published in November 2010 and Schedule 1A of the Petroleum and Gas (Production and Safety) Regulation 2004 (Qld), titled 'Mandatory conditions for resource authorities' according to Part 2A of the Petroleum and Gas (Production and Safety) Regulation 2004 (Qld).

²¹³ Queensland Government, *Land Access Code*, November 2010, pp 7-10, reproducing Schedule 1A of the Petroleum and Gas (Production and Safety) Regulation 2004 (Qld).

²¹⁴ *Petroleum and Gas (Production and Safety) Act 2004* (Qld) s 532.

Finding 18: The Committee finds that the relative bargaining strength of a landowner compared with a resource company is a significant issue in all jurisdictions.

5.33 The Land Access Code has been subject to review and reform twice since it commenced:

- In 2012, an independent Land Access Review Panel comprising agricultural and resource industry experts made 12 recommendations to government ‘to streamline the process where possible, to provide a fully informed platform for negotiating beneficial agreements and to resolve disputes efficiently.’²¹⁵ The Government of the day prepared a six-point action plan in response to this review.²¹⁶
- In late 2013, the Land Access Implementation Committee prepared a report for the Queensland Government to best implement the action plan and improve the Land Access Code’s effectiveness.²¹⁷

5.34 The Committee notes that the 2012 Land Access Review Panel developed a useful ‘matrix of interaction’ based on evidence received during the review. This is attached to this report at **Appendix 10**.²¹⁸

5.35 The complete Land Access Code document is provided at **Appendix 11**.

Finding 19: The Committee finds that land owners and resource companies should be encouraged to negotiate land access agreements through the use of alternative dispute resolution methods, rather than seeking redress through the court system.

Finding 20: The Committee finds that resource companies should be liable to pay for the reasonable legal and other associated costs of land owners during negotiations for land access.

²¹⁵ Queensland, Land Access Review Panel, *Land Access Framework – 12-month review: Report of the Land Access Review Panel*, February 2012, p 1.

²¹⁶ Available at: https://www.dnrm.qld.gov.au/_data/assets/pdf_file/0014/193100/qld-gov-response-land-access-framework.pdf. Viewed 12 May 2015.

²¹⁷ Available at: https://www.dnrm.qld.gov.au/_data/assets/pdf_file/0003/193089/land-access-implementation-committee-report.pdf. Viewed 12 May 2015.

²¹⁸ Queensland, Land Access Review Panel, *Land Access Framework – 12-month review: Report of the Land Access Review Panel*, February 2012, p 15.

GasFields Commission

- 5.36 The GFC was involved in the above review processes, including the creation of the Land Access Code. The Land Access Review Panel also recommended a review of the Land Access Framework, to be considered in consultation with the GFC.²¹⁹
- 5.37 The Chairman of the GFC, Mr John Cotter, advised the Committee on the critical aspects of the GFC's operations:

One of the two critical parts of the commission is its total independence. It was formed as an initiative of government; however, it is now owned by government. We report to Parliament, which is fairly unique in statutory bodies, we have our own legislation and we have significant powers such as the ability to review the performance and effectiveness of government legislation.

We cannot be directed by a government department. We do not report to a minister. I think that in itself has sent a very clear message that the government are serious about impartiality.²²⁰

- 5.38 The GFC has been able to monitor its success in providing independent advice, not through 'statistical figures', but through improved stakeholder relations:

[We] are seeing a better relationship between, firstly, the proponents, the communities and the directly affected people. There is not a doubt that, for instance, the agreements between companies now are much more fruitful, much better designed, and it is a business-to-business relationship...It is very much driven by the demand for people to substantiate their objection with fact and I think that is probably the key measure of our involvement.

The relationship between government, community, local government and industry is very close and very open.²²¹

- 5.39 Over 4000²²² land access agreements have been signed in Queensland, with no disputes having been referred to the Land Court for resolution.²²³ Since the Land

²¹⁹ Queensland Government, *Queensland Government Response to the Report of the Land Access Review Panel*, December 2012, p 18 (see footnote 215).

²²⁰ Mr John Cotter, Chairman, GasFields Commission Queensland, *Transcript of Evidence*, 12 September 2014, p 5.

²²¹ *Ibid*, p 6.

²²² According to APPEA figures to the end of 2013, 4516 agreements have been signed by landholders: APPEA, Media release, *Record number of land agreements signed between gas companies and Queensland farmers*, 17 April 2014.

Access Code was implemented, the relationship between farmers and exploration companies has improved from one of ‘anxiety and angst’ to one where there is a:

*reasonably thought out program where companies start a process of building a relationship, learning about the business on the property that they are going to work with, encouraging the property owner to understand what business the industry wants to do on their property, to going forward to how they deal with that as a business-to-business relationship. That has taken a considerable amount of time...The culture of the industry has changed dramatically in that area. There is no doubt about that. They have gone about recruiting better people to engage with landowners. They have gone about making it more of a partnership and an understanding. The land access code then laid down some very clear guidelines about how, and what, they could do.*²²⁴

- 5.40 Mr Cotter advised the Committee that, ‘before you talk about the economics or the impact, if there is a relationship built...it is the first step in developing how you are going to do business.’²²⁵ Mr Cotter added, for example, that:

one of the challenges we have in a lot of places [in Queensland] is that the powerlines that they put to these wells are where there is a lot of helicopter mustering; that in itself is a complex issue.

*We have worked with companies to make sure they run with ridge lines the way that the cattle flow. The companies do not have this understanding or knowledge; that is what they have to learn. That is, I think, the first step in developing these two business arrangements together.*²²⁶

Finding 21: The Committee finds that the establishment of an independent statutory body is the most appropriate means to address the inequity in bargaining power between land owners and resource companies during negotiations for access to land.

²²³ Mr John Cotter, Chairman, GasFields Commission Queensland, *Transcript of Evidence*, 12 September 2014, p 6. During 2012-13, no new appeals under the *Petroleum and Gas (Production and Safety) Act 2004* (Qld) were lodged and two were finalised: Land Court of Queensland, *Annual Report 2012-13*, p 12.

²²⁴ Mr John Cotter, Chairman, GasFields Commission Queensland, *Transcript of Evidence*, 12 September 2014, p 10.

²²⁵ Ibid, p 10.

²²⁶ Ibid, p 11.

Recommendation 5: The Committee recommends that the Government establish a statutory body similar to the Queensland GasFields Commission to act as an independent arbiter for land owners and resource companies in land access negotiations involving onshore shale gas.

Recommendation 6: The Committee recommends that the Government establish a working group, including land owner representatives and community leaders, to draft legislation for a statutory framework for land access agreements between land owners and resource companies. The framework should include provisions for an agreement template, compensation for land owners and the enforcement of mandatory access conditions using Queensland’s Land Access Code as a guide.

South Australia

- 5.41 Hydraulic fracturing for unconventional gas in South Australia is regulated by the Energy Resources Division of the Department of State Development (**DSD-ERD**). DSD-ERD is the lead agency involved in the development of unconventional gas projects in South Australia.
- 5.42 The government’s ‘Roadmap for Unconventional Gas Projects in South Australia’²²⁷ states that DSD-ERD encourages the industry to adhere to the Golden Rules (see paragraphs 3.29 to 3.35) and to engage in ‘early, effective and informative stakeholder consultation.’²²⁸ The Committee is aware that DSD-ERD also consults with other South Australian State Government regulators to share information and experiences.
- 5.43 DSD-ERD requires exploration companies to closely engage with the community. The statutory definitions of ‘environment’ and ‘owner’ in the *Petroleum and Geothermal Energy Act 2000 (SA) (PGEA)* are drafted in the broadest terms. Section 4 provides that:

environment includes –

(a) land, air, water (including both surface and underground water), organisms and ecosystems; and

(b) buildings, structures and cultural artefacts; and

(c) productive capacity or potential; and

²²⁷ This document was published in 2012 and since its release, DSD-ERD has convened six working groups, comprising of 440 members and six working groups, including industry, government, peak environmental bodies and Aboriginal groups, research institutions and individuals.

²²⁸ South Australia, Department for Manufacturing, Innovation, Trade, Resources and Energy, *Roadmap for Unconventional Gas Projects in South Australia*, December 2012, p 11.

(d) the external manifestations of social and economic life; and

(e) the amenity values of an area...

owner of land means each of the following (insofar as may be relevant in the circumstances of the particular case):

(a) a person who holds an estate in fee simple in the land;

(b) a person who holds a lease or licence over the land issued by the Crown;

(c) a person who is in possession of the land under a lease registered in the Lands Titles Registration Office or deposited in the General Registry Office and noted against the land;

(d) a person who has, by statute, the care, control or management of the land;

(e) a person who holds a tenement over or in relation to the land (including in relation to a stratum of the land), other than a speculative survey licence or a preliminary survey licence;

(f) without limiting a preceding paragraph, a person in actual possession of the land under a right of exclusive possession;

(g) a person who-

(i) holds native title in the land; or

(ii) is the registered representative of claimants to native title within the meaning of the Native Title (South Australia) Act 1994,

(with these paragraphs being in the alternative);

(h) a person of a class brought within the ambit of this definition by the regulations.²²⁹

5.44 Community consultation in South Australia occurs at two stages during activity approval: when the required Environmental Impact Report is developed and then again when Notice of Entry is provided. Part 10 of PGEA outlines when notice of entry on land must be provided to an owner of land and the owner's right to object to entry.

²²⁹ *Petroleum and Geothermal Energy Act 2000 (SA) s 4.*

- 5.45 The PGEA also provides the Minister with the power to ‘attempt to mediate’ to ‘arrive at mutually satisfactory terms’ for entry (section 62 PGEA). Similarly to the rights of landowners in Western Australia, the PGEA specifies that, if agreement cannot be reached, either party may apply to the Warden’s Court for resolution of the dispute.

United Kingdom: ‘the small, crowded island’

- 5.46 Despite the common origin in the legal systems of Australia and the UK, significant legislative differences have developed between the two countries in relation to the regulation of the unconventional gas industry and land access issues. In the Committee’s view, geological and societal differences have the effect that the UK’s experience with hydraulic fracturing is of limited practical value in Western Australia.
- 5.47 Onshore shale gas in the UK is mainly found in areas concentrated around the Bowland Shale in the Midlands and the Weald Basin in the south, as illustrated in **Figure 13**.

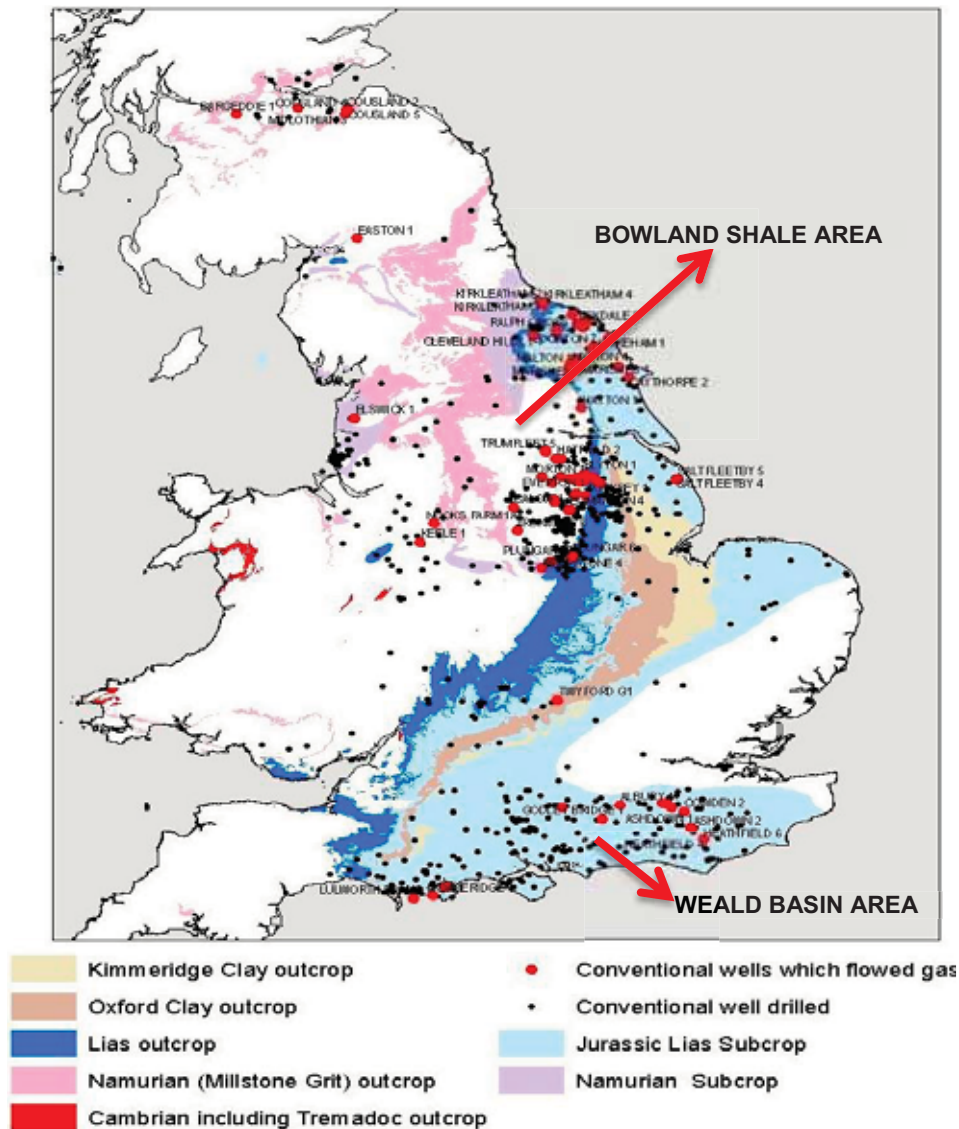


Figure 13. Main areas of prospective UK shale formations [Source: British Geological Survey, 2012]

5.48 Since the publication of the British Geological Survey’s (BGS) report for the Department of Energy and Climate Change,²³⁰ the focus of onshore shale gas has been on the Bowland Shale in central and northern Britain, where resources have been estimated at 1329 tcf (equating to 37.6 trillion cubic metres).²³¹ BGS also recently

²³⁰ British Geological Survey for the Department of Energy and Climate Change, *The Unconventional Hydrocarbon Resources of Britain’s Onshore Basins – Shale Gas*, 2010.

²³¹ British Geological Survey for the Department of Energy and Climate Change, *The Carboniferous Bowland Shale gas study: geology and resource estimation*, 27 June 2013, p 3. Note that this was not an estimate of the amount of commercially recoverable gas as BGS does not yet have sufficient knowledge of the basin’s geology and well flow rate to make that assessment.

found that there was no significant gas resource in the Jurassic shale of the Weald Basin in southeast England.²³²

- 5.49 Hydraulic fracturing for shale gas in the UK was formerly regulated by the Department of Energy and Climate Change (**DECC**). On 1 April 2015, certain functions passed from DECC to the Oil and Gas Authority (**OGA**), an executive agency created within DECC as a result of a review of the UK's offshore oil and gas sector.²³³
- 5.50 OGA is responsible for issuing licences and managing licensing policy (exploration and production) for oil and gas and for:
- exploration and production
 - fields and wells
 - infrastructure.²³⁴
- 5.51 Despite this recent transition, the process of obtaining consent to drill a well remains the same for conventional or unconventional gas wells. The licence to exploit onshore hydrocarbons is referred to as a 'Petroleum Exploration and Development Licence.' There is no specific or separate licensing regime for shale gas exploration that may involve hydraulic fracturing. Operators must also seek various permits from the local planning authority, the environmental regulator, the Health and Safety Executive, an independent well examiner and also advise BGS of the intent to drill for oil or gas.²³⁵

Trespass and the rights of landowners to refuse access to their land

- 5.52 Section 2 of the Petroleum Act 1998 (UK) vests all rights and ownership of petroleum resources (oil and gas) of the UK in the Crown, despite the common law principle that

²³² British Geological Survey for the Department of Energy and Climate Change, *The Jurassic shales of the Weald Basin: geology and shale oil and shale gas resource estimation*, 23 May 2014.

²³³ United Kingdom, Department of Energy and Climate Change, *Oil and Gas Authority Framework Document*, 1 April 2015, p 2.

²³⁴ United Kingdom, Oil and Gas Authority: About Us. Available at: <https://www.gov.uk/government/organisations/oil-and-gas-authority/about>. Viewed 14 May 2015 and Department of Energy and Climate Change, *Oil and Gas Authority Framework Document*, 1 April 2015, p 35.

²³⁵ United Kingdom, Department of Energy and Climate Change, *Onshore oil and gas exploration in the UK: regulation and best practice: England*, December 2013, pp 6-7. A detailed discussion of the various permissions and approvals required for hydraulic fracturing in the United Kingdom is beyond the scope of this report.

the owner of the resource also ‘owns to the heavens above and to the centre beneath.’²³⁶

- 5.53 Significant recent legislative amendments in the UK have removed the requirement for companies to obtain a landowner’s consent before accessing shale gas under their land.
- 5.54 Section 43 of the Infrastructure Act 2015 (UK) created a special category of ‘deep-level’ land, from which petroleum and geothermal energy can be extracted without a landowner’s consent:

Petroleum and geothermal energy: right to use deep-level land

(1) A person has the right to use deep-level land in any way for the purposes of exploiting petroleum or deep geothermal energy.

(2) Land is subject to the right of use (whether for the purposes of exploiting petroleum or deep geothermal energy) only if it is –

(a) deep-level land; and

(b) within a landward area.

(3) But that does not prevent deep-level land that is within a landward area from being used for the purposes of exploiting petroleum or deep geothermal energy outside a landward area.

(4) Deep-level land is any land at a depth of at least 300 metres below surface level. [Committee emphasis]

- 5.55 Section 44 of the Infrastructure Act 2015 (UK) provides further detail of how the right to use deep-level land may be exercised, including drilling or fracturing deep-level land, installing infrastructure or passing any substance through the deep-level land. The legislative right of use in section 43 is limited so that it is no different to a right granted by the landowner. A company benefitting from access must therefore comply with all other regulatory regimes, such as planning permissions, environmental permits and other statutory obligations.²³⁷

- 5.56 The requirement to notify individual landowners prior to companies accessing unconventional gas resources under land was removed by subsidiary legislation (the Town and Country Planning (Development Management Procedure and Section 62A

²³⁶ *Cujus est solum ejus est usque ad coelum, et ad inferos*: whoever has the soil, also owns to the heavens above and to the centre (hell) beneath; it is a general statement about the physical extent of land ownership at common law. See for example *Commonwealth v New South Wales* (1923) 33 CLR 1.

²³⁷ Infrastructure Act 2015 (UK), *Explanatory Notes*, p 32.

Applications) (England) (Amendment No. 2) Order 2013), which generated much controversy in the UK.²³⁸

- 5.57 The House of Lords Secondary Legislation Scrutiny Committee scrutinised the Order and noted that:

*the timing which the Government followed for laying the Order and bringing it into force left scant opportunity for Parliament to scrutinise the instrument before it took effect. Given that “fracking” is a highly controversial technique, and that the Order streamlines procedures for notifying interested parties whose land may be affected by the technique, we find it regrettable that the opportunity for Parliamentary scrutiny was curtailed in this way.*²³⁹

- 5.58 The House of Lords Secondary Legislation Scrutiny Committee also referred to the submission from the National Trust that ‘notification to landowners of a planning application relating to their land is an important principle underpinning the balance of interests which is struck by the planning regime.’²⁴⁰
- 5.59 The Committee notes the House of Lords Secondary Legislation Scrutiny Committee’s findings and would not expect a similar situation to occur in Western Australia.
- 5.60 The Infrastructure Act 2015 (UK) also made changes to the way that the Petroleum Act 1998 (UK) deals with hydraulic fracturing, including a range of mandatory conditions which must be met before any hydraulic fracturing can be carried out.²⁴¹
- 5.61 One of the statute’s objects was to remove the legal uncertainty surrounding trespass that arose from the 2010 judgment of the UK Supreme Court in *Star Energy Weald Basin Limited and another v Bocardo SA*.²⁴² The question in that case was whether an

²³⁸ The Telegraph, *Pro-fracking planning reforms rushed through despite strong opposition, Lords warn*. Available at: <http://www.telegraph.co.uk/news/earth/energy/fracking/10605859/Pro-fracking-planning-reforms-rushed-through-despite-strong-opposition-Lords-warn.html>. Viewed 29 January 2014.

²³⁹ United Kingdom, House of Lords, Secondary Legislation Scrutiny Committee, Report 28, *Draft Town and Country Planning (Fees for Applications, Deemed Applications, Requests and Site Visits) (England) (Amendment) Regulations 2014, Town and Country Planning (Development Management Procedure and Section 62A Applications) (England) (Amendment No. 2) Order 2013*, 30 January 2014, p 4.

²⁴⁰ *Ibid*, p 5.

²⁴¹ For example, no hydraulic fracturing to be carried out at depths less than 1000m, independent well inspections and groundwater and emissions monitoring: section 4A, Petroleum Act 1998 (UK).

²⁴² *Star Energy Weald Basin Limited and another v Bocardo SA* [2010] UKSC 35. The decision was based on the Petroleum (Production) Act 1934 (UK), which was repealed by the passage of the newer 1998 statute.

oil company was liable for trespass for drilling horizontally under a landowner's land from whom consent had not been obtained.²⁴³

5.62 The court took it as 'common ground' that the landowner (Bocado SA):

*did not, and does not, own any of the petroleum in the reservoir that is situated beneath its land. Nor does it possess, or have any right to possess, any of that petroleum.*²⁴⁴

5.63 The question of trespass instead turned on several issues, including whether Bocado SA's title to the land 'extends down to the strata below the surface through which the three wells and their casing and tubing pass.' The Supreme Court ultimately held unanimously that Star Energy Weald Basin Ltd (the exploration company who was responsible for the wells) had, in fact, committed a trespass through the presence of its three hydraulic fracturing wells, their casing and tubing under Bocado SA's land.

5.64 The Committee is not aware of any Australian legal authorities where a similar question of a trespass has been considered as a result of hydraulic fracturing encroaching under a landowner's land.

USA: ownership of oil and gas

5.65 In contrast to both the UK and Australia, in the USA, landowners own the hydrocarbons under their land and therefore also the right to exploit them.²⁴⁵ Since the landowner owns all resources under the land (including oil, gas and minerals), they also have the right to refuse access to an exploration company who offers to develop these resources.

5.66 The principal regulatory authority for developing unconventional gas in the USA is the state government, with federal input largely limited to environmental monitoring. Oil and gas laws vary by state in the USA. The Committee visited Pennsylvania and Texas, two significant shale gas states, as part of this inquiry.

Pennsylvania and the Marcellus Shale

5.67 The Committee has spoken with residents in Dimock Township in Susquehanna County, Pennsylvania, who were directly affected by drilling for unconventional gas on their lands.

²⁴³ The UK Supreme Court appeal was a result of Bocado SA appealing the Court of Appeal's reduction in the amount of damages awarded and the respondent taking the opportunity to cross-appeal on the issue of trespass.

²⁴⁴ [2010] UKSC 35, p 3.

²⁴⁵ A detailed discussion of the 'rule of capture' or historical basis for the private ownership of underground resources in the USA is beyond the scope of this report, but can be explored further with reference to: DW Miller, 'The Historical Development of the Oil and Gas Laws of the United States', *California Law Review*, vol 51, issue 3, 1963, pp 506-534.

- 5.68 The Marcellus Shale, one of the largest identified shale plays in the USA, runs underneath most of Pennsylvania, including Dimock, as well as extending into the surrounding states (see **Figure 14**). Dimock residents informed the Committee that the Marcellus Shale is estimated to yield at least 30 years of gas production, with this estimated figure increasing over time.
- 5.69 Dimock’s small community²⁴⁶ has been the centre of much of the controversy surrounding hydraulic fracturing, both as a result of issues related to fugitive methane emissions and disputes regarding access to land and negotiations with drilling companies.²⁴⁷



Figure 14. Lower 48 states shale plays [Source: Energy Information Administration, based on data from various published studies, 2011]

²⁴⁶ As at 2010, 1497 residents: <http://www.dimockpa.org/about.html>. Viewed 14 May 2015.

²⁴⁷ In 2009, there were instances reported of fracturing fluids being spilled at a well pad in Dimock, which resulted in water contamination and fish deaths: ProPublica, *Frack Fluid Spill in Dimock Contaminates Stream, Killing Fish*, 21 September 2009. There were also reports of fugitive methane contaminating residential bores which were the subject of consent orders in 2010 between Cabot Oil and Gas Corporation and Pennsylvania’s Department of Environmental Protection. The consent orders are available at http://www.cabotog.com/pdfs/FinalA_12-15-10.pdf. Viewed 14 May 2015.

- 5.70 The Committee was informed that, as a result of the private ownership of resources in Pennsylvania, negotiations between landowners and the company can vary widely in terms of compensation and terms.²⁴⁸
- 5.71 Dimock has been significantly affected by the presence of shale gas in the area. Residents informed the Committee that the development of shale gas resources in the township has created jobs and brought prosperity to the county. Ongoing litigation related to land access and potential water contamination has, however, politicised the issue and divided residents.²⁴⁹
- 5.72 Cabot Oil and Gas Corporation is the main operator with a presence in Dimock Township, with drilling also occurring at various stages within Susquehanna County, including wells which have been completed and are now remediated sites (see **Figures 15 and 16**).



Figure 15. Remediated onshore shale gas well on private land in Dimock, Pennsylvania (from different angles)

[Source: Committee site visit, 27 May 2014]

²⁴⁸ The Committee was advised that some residents in Dimock were initially offered US\$25/acre for access to their land for drilling, but that some two years later that figure was rumoured to be up to US\$2500/acre: Committee site visit to Dimock, 27 May 2014.

²⁴⁹ There is an area within the township ('the box') where ongoing litigation related to water contamination means that no drilling is permitted whilst monitoring continues: Committee site visit, 27 May 2014.



Figure 16. Remediated onshore shale gas well on private land in Dimock, Pennsylvania (from different angles)
[Source: Committee site visit, 27 May 2014]

Barnett Shale in Texas

- 5.73 Texas is an area of the world with similar geographic considerations to Western Australia, where drilling with hydraulic fracturing originally occurred in sparsely populated areas with limited existing infrastructure. Of the 254 counties in Texas, all have a pipeline facility, with a total of 425 939 miles of pipeline in Texas, the ‘largest pipeline infrastructure in the nation.’²⁵⁰
- 5.74 The hydraulic fracturing industry in Texas is regulated by the Railroad Commission of Texas. Under Texas law, landowners have the right to sell the surface rights to their land, but retain the rights to exploit the mineral under their land (or vice versa). Where the mineral rights have been sold, the owner of the surface land must give the mineral owner reasonable access to the surface estate to explore, develop and produce any oil or gas under the property.
- 5.75 Texas has one of the ‘most comprehensive rules for disclosure of chemical ingredients used in hydraulic fracturing fluids’ in the USA.²⁵¹ The Texas Administrative Code Hydraulic Fracturing Disclosure Rule of 2012 requires companies to disclose all chemical ingredients and water volumes used in hydraulic fracturing to the FracFocus registry (see paragraph 6.42). Texas also has a comprehensive program in place to

²⁵⁰ This is equivalent to 685 482 kilometres: Railroad Commission of Texas, *Pipeline Safety*. Available at: <http://www.rrc.state.tx.us/pipeline-safety/>. Viewed 18 May 2015.

²⁵¹ State of Texas, Railroad Commission, *Hydraulic Fracturing*. Available at: <http://www.rrc.state.tx.us/about-us/resource-center/faqs/oil-gas-faqs/faq-hydraulic-fracturing/>. Viewed 2 February 2015.

plug orphaned wells, using funds collected from operators as part of their drilling permits (see paragraph 8.51).

5.76 The concerns of the Texan community regarding hydraulic fracturing are similar to those expressed by members of the public in Western Australia: fears of groundwater contamination from chemicals used during the process and of the drought in Texas being exacerbated by companies taking water for mining activities.²⁵²

5.77 The amount of water used in hydraulic fracturing varies widely between states in the USA, ranging from as little as 9.8 kilolitres to 36 339 kilolitres, with the average volume used having increased between 2000 and 2014.²⁵³ Hydraulic fracturing water use in Texas was amongst the highest in the country. **Figure 17** shows the average volumes of water used across the USA.

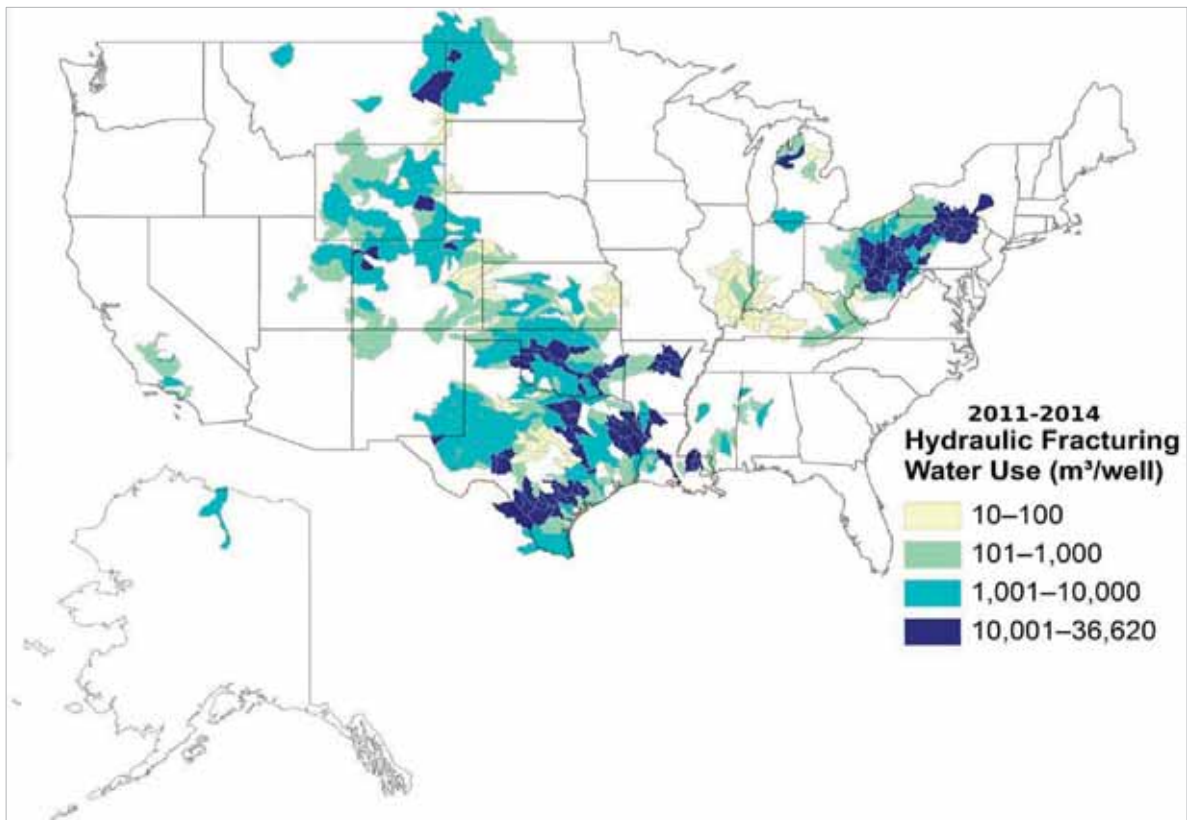


Figure 17. Average water use in hydraulic fracturing per oil and gas well in watersheds across the USA [Source: United States Geological Survey, June 2015]

²⁵² State of Texas, Railroad Commission, *Frequently Asked Questions: Hydraulic Fracturing*. Available at: <http://www.rrc.state.tx.us/about-us/resource-center/faqs/oil-gas-faqs/faq-hydraulic-fracturing/>. Viewed 2 July 2015.

²⁵³ United States Geological Survey, *Water Used for Hydraulic Fracturing Varies Widely Across United States*, Media Release, 30 June 2015. Available at: <http://www.usgs.gov/newsroom/article.asp?ID=4262>. Viewed 2 July 2015.

INFRASTRUCTURE ISSUES RELEVANT TO CONDUCTING HYDRAULIC FRACTURING

- 5.78 Western Australia is a challenging environment for the commercial production of onshore gas projects, due in part to limited energy infrastructure:

*Western Australia's limited energy infrastructure, relatively small energy market and geographic remoteness of gas resources, makes it a challenging environment in which to commit to full commercial production of any onshore gas project.*²⁵⁴

- 5.79 DMP is of the view, however, that 'Western Australia has significant established infrastructure including modern seaports and international airports' with pipelines including the Dampier to Bunbury Natural Gas Pipeline and the Parmelia Gas Pipeline connecting the Dongara gasfields to the wider Perth area.²⁵⁵

- 5.80 The Committee notes that the challenges faced in different areas of Western Australia can differ hugely: whilst remoteness is a major factor in the Canning Basin, proximity to communities is the main issue facing development of the Perth Basin. The ACOLA Report states, for example, that:

pipeline infrastructure into the Canning Basin is currently non-existent...the road network in the Canning is also limited and existing roads would need to be upgraded...

*The development of a shale gas industry in Australia will rely heavily on imported equipment and skills.*²⁵⁶

- 5.81 In general terms, the basic infrastructure required to establish hydraulic fracturing for unconventional gas does not significantly differ from that of a conventional gas development, apart from scale. Infrastructure required may include: drilling rigs, wellpads, gas processing plants, pipelines, roads and worker accommodation.²⁵⁷

²⁵⁴ Submission 105 from Department of Mines and Petroleum, 3 October 2013, p 3.

²⁵⁵ Department of Mines and Petroleum, *Western Australia's Petroleum and Geothermal Explorer's Guide: 2014 Edition*, September 2014, p 21. See also, Western Australia, Legislative Assembly, Standing Committee on Economics and Industry, Report 2, *The economic impact of floating LNG on Western Australia – volumes 1 and 2*, May 2014.

²⁵⁶ ACOLA Report, pp 80 and 84.

²⁵⁷ *Ibid*, pp 74-82.

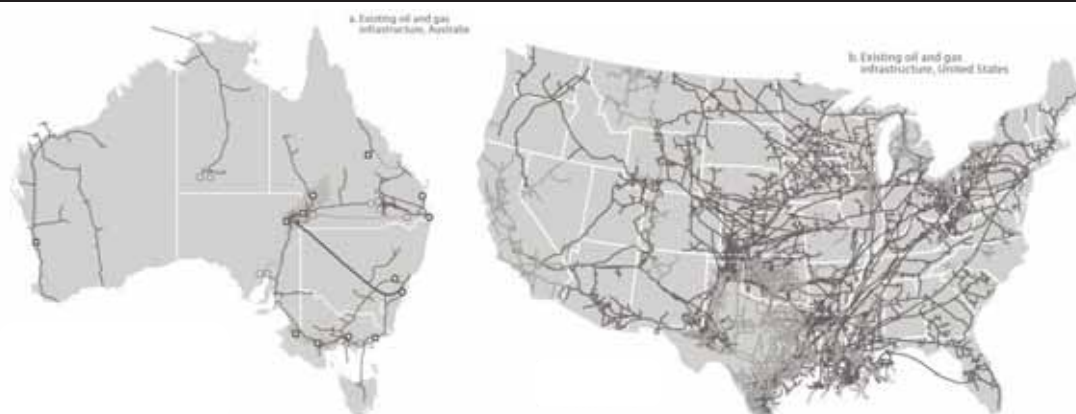


Figure 18. Maps of Australia and USA to illustrate differences in the density of existing oil and gas infrastructure [Source: ACOLA Report, 2013]

- 5.82 The Committee has observed the impact of Western Australia’s geography upon the feasibility of developing unconventional gas resources, particularly in the Canning Basin in the Kimberley. In 2012, a state agreement with Buru Energy Limited and Mitsubishi Corporation was signed to facilitate the development of a domestic gas project and pipeline in the Canning Basin.²⁵⁸
- 5.83 The remoteness of the region, lack of existing infrastructure and seasonal implications will present unique challenges for any exploration company that intends to use hydraulic fracturing for unconventional gas in the north of Western Australia.

COMPARISONS WITH WESTERN AUSTRALIA

- 5.84 The Committee has found that concerns about the volume of water and the types of chemicals used during hydraulic fracturing are shared in many nations where hydraulic fracturing occurs (or is proposed).²⁵⁹ Differences in local geography and the size and geology of the shale formations, however, can mean that it is not always useful to compare the Western Australian experience with hydraulic fracturing to that in other countries.
- 5.85 **Figure 19** illustrates the differences in size between Australia, the USA and UK.
- 5.86 The Committee notes the impact of infrastructure on densely-populated areas, such as in the UK, where truck noise and increased traffic on the road affects land use and visual amenity of the land. This is likely not to be a significant issue in the sparsely-populated area of the Canning Basin, but would be a primary consideration in the development of a shale gas industry in the areas of the Midwest and the Perth Basin (see paragraph 3.22).

²⁵⁸ Submission 105 from Department of Mines and Petroleum, 3 October 2013, p 9.

²⁵⁹ See for example, reports from The Royal Society/Royal Academy of Engineering (UK), Parliamentary Commissioner for the Environment (NZ), Council of Canadian Academies (Canada) and the Australian Council of Learned Academies (Australia).

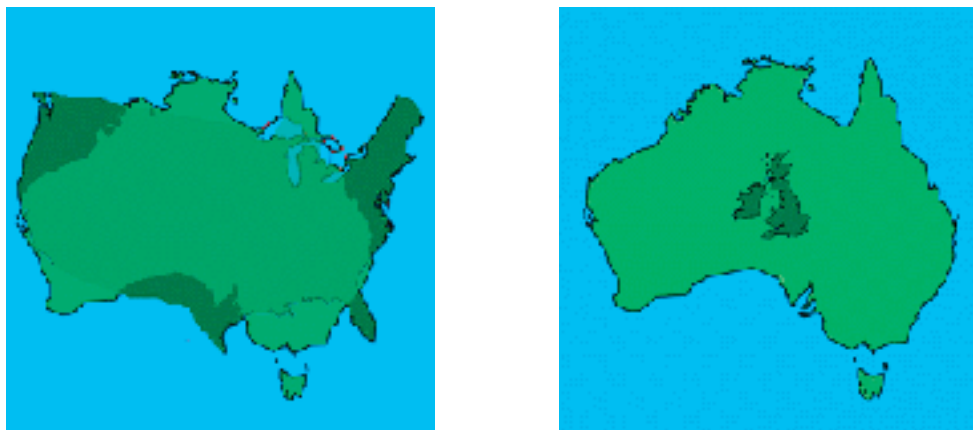


Figure 19. Comparative sizes of Australia, USA and United Kingdom [Source: Geoscience Australia, 2015]

- 5.87 The different methods used in well construction can also have an impact on the risks associated with hydraulic fracturing. In the USA, well construction requirements vary by state: for example, Pennsylvania and Texas have a requirement to cement casing to a depth of 75 feet (approximately 23 metres) below any aquifers.²⁶⁰ In Alberta, Canada there have been instances of well failure where wells had no casing at all or only a single layer of pipeline casing to separate hydrocarbons from the environment.²⁶¹
- 5.88 The UK's standard practice is to have three strings of casing with at least two of these (the intermediate and production casings) passing through freshwater zones, thereby isolating them. UK best practice also involves cementing casings to the surface.²⁶²
- 5.89 In Western Australia, operators must use a minimum of three strings of casing (conductor, surface and production casing or liner) with an optional intermediate casing for deeper wells.²⁶³ According to DMP, these requirements represent 'international standards' for well integrity.²⁶⁴

²⁶⁰ Royal Society and Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 26.

²⁶¹ TL Watson and S Bachu, 'Evaluation of the potential for gas and CO₂ leakage along wellbores', *Society of Petroleum Engineers*, vol 24, issue 1, 2009, p 123.

²⁶² Royal Society and Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 26.

²⁶³ Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, pp 8-9. A Well Management Plan submitted by an operators pursuant to Schedule 1 of the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 must include the information in Schedule 1, which includes details of casing and barriers to be used in a well.

²⁶⁴ Department of Mines and Petroleum, *Natural Gas from Shale and Tight Rocks Fact Sheet: Well design and integrity*, September 2014.

Finding 22: The Committee finds that Western Australia’s requirements for operators to use a minimum of three casing strings during drilling represents international best practice in the onshore gas industry.

5.90 The Committee also makes the following concluding finding in relation to the experience of jurisdictions overseas with the onshore shale gas industry:

Finding 23: The Committee finds that it is beneficial for Western Australian regulators and operators to look to unconventional gas industries in other jurisdictions and learn from the more established stakeholders in the global shale gas market.

CHAPTER 6

CHEMICALS USED IN HYDRAULIC FRACTURING

There has been much criticism of slickwater fracturing, particularly the huge volume of water used and the risk of contamination of water resources. Yet, compared to conventional fracturing, there is much more awareness regarding the impact of the chemicals used, and environmentally less harmful chemicals are continually being developed. Furthermore, there is a continual development of the chemicals that enable the reuse of produced or brackish water, vastly reducing the volume of fresh water used. This provides the community with a form of hydraulic fracturing that is constantly moving towards environmental acceptability.

Dr Tina Hunter,

*All hydraulic fracturing is equal, but some is more equal than others: an overview of the types of hydraulic fracturing and the environmental impacts*²⁶⁵

- 6.1 The community has informed the Committee of its concerns with the use of chemicals during hydraulic fracturing which have been described as: ‘toxic,’²⁶⁶ ‘dangerous,’²⁶⁷ ‘carcinogens,’²⁶⁸ or ‘endocrine disruptors.’²⁶⁹ The impact of the chemicals used during the process is therefore one of the fundamental issues that the Committee has examined and considered.
- 6.2 The Committee focused on the types of chemicals used during the process of hydraulic fracturing, the volumes of chemicals used and how this aspect of the industry is regulated in Western Australia.
- 6.3 The Committee has learned of innovations and advancements in the use of chemicals in hydraulic fracturing, which will also be discussed in this chapter.

TYPES OF CHEMICALS USED DURING HYDRAULIC FRACTURING

- 6.4 There is much misinformation in the public domain regarding the types of chemicals that are routinely used in Australia for hydraulic fracturing. The Committee distinguishes between the chemicals used overseas (specifically, in the USA) and those which are used in Western Australia.

²⁶⁵ T Hunter, ‘All hydraulic fracturing is equal, but some is more equal than others: an overview of the types of hydraulic fracturing and the environmental impacts’, *Australian Environment Review*, April 2014, p 69.

²⁶⁶ Submission 27 from Eileen Whitehead, 18 September 2013.

²⁶⁷ Submission 50 from Alliance for a Clean Environment Inc., 19 September 2013.

²⁶⁸ Submission 34 from Public Health Association Australia (WA Branch), 20 September 2013.

²⁶⁹ Submission 91 from Dr Ann-Maree Lynch Calnan, 20 September 2013.

6.5 DMP advises that the chemicals used during a hydraulic fracturing operation typically fall within the following categories:²⁷⁰

Acid	Friction reducer	Surfactant	Gelling agent
Clay control	Scale inhibitor	Cross-linker	Buffers
Breaker	Iron control	Corrosion inhibitor	Biocide

6.6 These types of chemicals can range from household or food-related products (such as hydrochloric acid or acetic acid) to complex organic compounds with solely industrial applications (for example, ethylene glycol or tetrakis hydroxymethyl-phosphonium sulphate).²⁷¹ Many concerns expressed by the community relate to the use of these particular chemicals during the hydraulic fracturing process, which may be unfamiliar to those outside the industry and therefore worrying.

6.7 Industrial chemicals must be listed on the Australian Inventory of Chemical Substances administered by the Commonwealth Department of Health. Chemical use is otherwise regulated at the State level by DMP through its chemical disclosure and environmental risk assessment regimes. Regulation 15(9) of the PGERE Regulations provides that:

The implementation strategy^[272] must include details of any chemicals or other substances that may be –

(a) in, or added to, any treatment fluids to be used for the purposes of drilling or hydraulic fracturing undertaken in the course of the petroleum activity; or

(b) otherwise introduced into a well, reservoir or subsurface formation in the course of the petroleum activity.

6.8 The Committee notes that regulation 11(8) of the PGERE Regulations requires operators to include a summary of the implementation strategy in the summary EP (which includes chemical disclosure information). Currently, only the summary EP is made available to the public on DMP's website and there is a delay of two to three weeks between DMP's approval of the EP and the summary being published on the

²⁷⁰ Department of Mines and Petroleum, *Natural Gas from Shale and Tight Rocks Fact Sheet: Hydraulic fracture stimulation*, March 2015, p 1. The Committee notes that this list is not exhaustive and demulsifiers, oxygen scavengers, pH adjusters, weighting agents, base fluids and lubricants may also be used: Department of Mines and Petroleum, *Chemical Disclosure Guideline*, August 2013, p 5.

²⁷¹ Commonly used in the USA and in Australia, tetrakis hydroxymethyl-phosphonium sulphate is a biocide, used to eliminate bacteria in water that may produce corrosive by-products: FracFocus, *What Chemicals Are Used*. Available at: <http://fracfocus.org/chemical-use/what-chemicals-are-used>. Viewed 14 May 2015. The compound is also used in industrial textile manufacture.

²⁷² 'Implementation strategy' is defined in regulation 15 as part of the environment plan for any approved petroleum activity (such as hydraulic fracturing) and 'must include measures to ensure that the environmental performance objectives and environmental performance standards in the environment plan are met': Petroleum And Geothermal Energy Resources (Environment) Regulations 2012 r 15(2).

internet.²⁷³ DMP has advised that it plans to implement legislative and administrative changes to move towards greater transparency so that ‘the full Environment Plan, which has full chemical disclosure, [is] available to the public after approval by DMP.’²⁷⁴

- 6.9 Petroleum operators must provide information to DMP relating to chemical toxicity and copies of Material Safety Data Sheets for each chemical identified.²⁷⁵ EP are a requirement pursuant to Division 1 of Part 2 of the PGERE Regulations, which makes it an offence to carry out an activity without an EP or contrary to the relevant EP.²⁷⁶
- 6.10 DMP has submitted that the policy framework related to chemical use and regulation in Western Australia is based on:

*a decision taken some years ago that in this State, that we were going to set the bar high and that it was full chemical disclosure. So, a very strong message given to companies, if you are going to come and operate in this State, that that was the basis on which it was going to happen.*²⁷⁷

WHEN CHEMICALS ARE USED

- 6.11 Because hydraulic fracturing is not a continuous process, water and the additive chemicals are needed periodically during drilling and then at each fracturing stage. There are generally three stages of well development: exploration, evaluation and production. Hydraulic fracturing may be required at each stage which, in turn, means that chemicals may be used many times during the development of a single well.²⁷⁸

QUANTITIES OF CHEMICAL USED

- 6.12 The ratio of chemicals to water used can vary between projects, but according to DMP, fluids generally contain 90 per cent water, 9.5 per cent sand (or other proppant) and 0.5 per cent chemicals.²⁷⁹ **Figure 20** illustrates the different volumes of fluid used during hydraulic fracturing.

²⁷³ Letter from Mr Richard Sellers, Director General, Department of Mines and Petroleum, 8 September 2015, p 2.

²⁷⁴ Ibid, p 2.

²⁷⁵ Submission 105 from Department of Mines and Petroleum, 3 October 2013, p 12.

²⁷⁶ ‘Petroleum activity’ is defined in regulation 4 and includes hydraulic fracturing. See also paragraph 4.13.

²⁷⁷ Ms Michelle Andrews, Deputy Director General Strategic Policy, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 4.

²⁷⁸ Department of Mines and Petroleum, *Natural Gas from Shale and Tight Rocks: an overview of Western Australia’s regulatory framework*, February 2014, p 7.

²⁷⁹ Ibid, p 8.

6.13 The Committee notes that, despite the numerical figure of half a per cent appearing to be a very small amount on paper, in quantitative terms this amount can be significant.

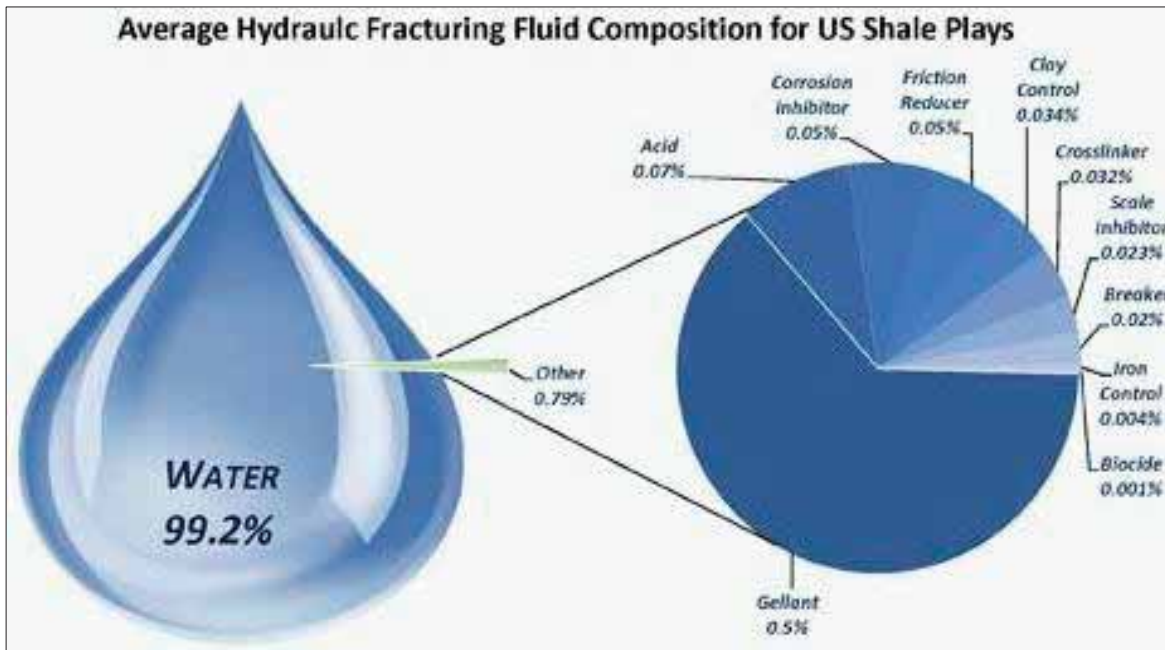


Figure 20. Average hydraulic fracturing fluid composition for US shale plays [Source: FracFocus.org]

6.14 The risks and impacts of hydraulic fracturing for unconventional gas are the greater volume of water and chemicals used (compared to conventional gas extraction) and the challenges associated with preventing spills, emissions or other environmental impacts.²⁸⁰

6.15 In the Perth Basin, exploration indicates that the probable number of hydraulic fracturing stages per vertical well (of up to three kilometres depth) would likely be three stages.²⁸¹ During hydraulic fracturing, this equates to around 6000 kilolitres of fluid per well during each stage.²⁸²

6.16 DMP has confirmed that the actual amounts of chemicals and water used during a typical hydraulic fracturing stage are as follows (based on figures from FracFocus, see **Figure 20**):

Water	5952 kilolitres	Cross-linker	2 kilolitres
Gel	30 kilolitres	Scale inhibitor	1.4 kilolitres

²⁸⁰ AEA Technology, Report for European Commission DG Environment, *Support to the identification of potential risks for the environment and human health arising from hydrocarbons involving hydraulic fracturing in Europe*, 10 August 2012, p vii.

²⁸¹ Department of Mines and Petroleum, *Natural Gas from Shale and Tight Rocks Fact Sheet: Water use and management*, September 2014, p 1.

²⁸² 6000 kilolitres is used during hydraulic fracturing; approximately 1000 kilolitres during drilling. One kilolitre = 1000 litres.

Acid	4.2 kilolitres	Breaker	1.2 kilolitres
Corrosion inhibitor	3 kilolitres	Iron control	240 litres
Friction reducer	3 kilolitres	Biocide	60 litres
Clay control/salt	2 kilolitres		

- 6.17 The amount or volume of chemicals used in hydraulic fracturing activity depends on the specific fluid characteristics sought, water and rock chemistry, the depth and length of the drill hole and how many stages of fracturing occur.²⁸³

Finding 24: The Committee finds that, whilst the amount of chemicals used in hydraulic fracturing fluid can be very large, the proportion of chemical to water and proppant is heavily diluted.

- 6.18 The amount of flowback that returns after a successful fracture stimulation can range from 30 to 50 per cent initially and even up to 70 per cent, depending on the geology of the formation. Some drilling fluid will remain within the formation, while the produced water which returns to surface can also include compounds that were not part of the drilling fluid: NORM or salts.
- 6.19 ACOLA advises that ‘it has been cited that hydraulic fracturing fluid left behind poses little or no environmental risk since it is trapped at great depth and cannot migrate from the formation.’²⁸⁴

ENVIRONMENTAL RISK ASSESSMENTS OF CHEMICALS

- 6.20 The chemical risk assessments that DMP conducts range from a simple assessment of general products to a more detailed risk assessment of the chemicals used in ‘down hole’ activities.²⁸⁵
- 6.21 DMP undertakes case-by-case assessment of environmental risks. DMP ‘considers it inappropriate to present a generic list of products and chemicals that would generally require environmental risk assessment.’ There are examples, however, where an environmental risk assessment will ‘generally be required’:
- where the products or chemicals:
 1. meet criteria for being ‘harmful’, ‘toxic’ or ‘very toxic’ to either human health or the environment; or

²⁸³ Department of Mines and Petroleum, *Prepared Draft Responses to Questions for Committee Hearing 25 August 2015*, tabled on 25 August 2015, p 6.

²⁸⁴ ACOLA Report, p 59.

²⁸⁵ Department of Mines and Petroleum, *Environmental Risk Assessment of Chemicals used in WA Petroleum Activities Guideline*, August 2013, p 17.

2. are a known carcinogen, mutagen or toxic to reproduction, fertility or development; or
 3. meet criteria for being persistent or bioaccumulative; and
 - where there is risk, uncertainty or complexity associated with the use of the products or chemicals.²⁸⁶
- 6.22 Not all chemicals used in down-hole activities will necessarily require any environmental risk assessment. DMP advised that an environmental risk assessment is not required for chemicals used onshore if:
- the product or chemical is comprised of natural ingredients (for example, water, plant material, cellulose, sand, natural clays)
 - the product or chemical is an inert, man-made substance (for example, ceramics, glass, mix/blend of natural products)
- or
- the products or chemicals:
 1. do not meet criteria for being ‘harmful’, ‘toxic’, or ‘very toxic’ to human health and/or the environment
 2. are not classed as a known carcinogen, mutagen or toxicant to reproduction, fertility or development
 3. do not meet criteria for being persistent or bioaccumulative.²⁸⁷

BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE (BTEX)

- 6.23 Most community concern raised during the inquiry related to the use of BTEX chemicals in hydraulic fracturing operations and their risk to humans. BTEX chemicals can occur naturally in the environment (for example, in crude oil) but are also produced by human activity related to motor vehicle and aircraft emissions and through industry and consumer product manufacture (such as paints, lacquers, inks, cosmetics and pharmaceuticals).²⁸⁸

²⁸⁶ Department of Mines and Petroleum, *Environmental Risk Assessment of Chemicals used in WA Petroleum Activities Guideline*, August 2013, p 18. The Guideline contains detailed information and definitions of the terms used in the paragraph above.

²⁸⁷ Ibid, p 17.

²⁸⁸ F Leusch & M Bartkow, *A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids*, Griffith University Smart Water Research Centre, 17 November 2010, p 2.

- 6.24 Once released in the environment, BTEX chemicals usually evaporate quickly into the air and can dissolve in water, leading to concerns about the potential impact of BTEX on air quality and water contamination.²⁸⁹ BTEX chemicals are also found to occur naturally in underground formations, such as hydrocarbon deposits. Hydraulic fracturing for unconventional gas, therefore, can bring BTEX chemicals to the surface in flowback.²⁹⁰
- 6.25 AWE Limited submitted data that it commissioned from environmental consultants related to the presence of BTEX at its Woodada-Deep 1 well in the Perth Basin.²⁹¹ AWE Limited's data found that there were no BTEX compounds reported in any of the samples during groundwater monitoring and the levels of BTEX found in air quality testing were minor compared to those normally found in remote rural areas or industrial areas. The data below illustrates the relative levels of BTEX at various reference sites and at Woodada-Deep 1:²⁹²

Location	Compound			
	Benzene	Toluene	Ethylbenzene	Xylenes
Woodada Deep-1	0.51	0.59	1.01	0.22
Remote rural area	0.2 - 16	0.5 - 260	0.2 - 1.6	<0.1 - 3
Industrial centre with high traffic density	Up to 349	Up to 1,310	Up to 360	Up to 775
Refuelling a car at a service station	Up to 10,000	Up to 9000	-	-

Notes: concentrations reported in micrograms per cubic metre (μm^3)

- 6.26 The use of BTEX chemicals as additives in hydraulic fracturing fluids has decreased since the early 2000s in the USA, as safer alternatives meant that industry became more willing to discontinue its reliance on BTEX chemicals in onshore gas

²⁸⁹ F Leusch & M Bartkow, *A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids*, Griffith University Smart Water Research Centre, 17 November 2010, p 1.

²⁹⁰ The Committee notes the recent incident in NSW where BTEX chemicals were detected in samples of flowback from AGL Upstream Investments Pty Ltd's CSG operations at its Waukivory Pilot Wells. The BTEX found in flowback was a result of the compounds occurring naturally within the coal seams being fractured and the NSW Environmental Protection Authority concluded that 'the chemicals and water used in the fracture process are not the likely source of the BTEX concentrations recorded from the Pilot Wells. Provided flowback water is removed and sent to an appropriate facility for further treatment and disposal it should not pose an unacceptable risk to the environment': NSW Environmental Protection Authority, *AGL Gloucester – Investigation Report into the Detection of BTEX in Flowback Water from Waukivory Pilot Wells*, 4 March 2015, p 5.

²⁹¹ Submission 113 from AWE Limited, 7 October 2013, pp 10-14. AWE Limited engaged Gemec Environmental Consultants to conduct water and air quality monitoring at its well sites and retention ponds.

²⁹² Ibid, p 13. Reference data in the table is from F Leusch & M Bartkow, *A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids*, Griffith University Smart Water Research Centre, 17 November 2010.

operations.²⁹³ In Australian jurisdictions, the use of BTEX chemicals during hydraulic fracturing operations has been specifically banned in several States, namely:

- Queensland, through amendments to the *Environmental Protection Act 1994* (Qld) in 2010²⁹⁴
- New South Wales, through the policy document ‘Ban on Use of BTEX compounds in CSG activities’, administered by the New South Wales Department of Trade & Investment²⁹⁵
- Victoria, by the provisions of the *Resources Legislation Amendment (BTEX Prohibition and Other Matters) Act 2014* (Vic) (assented to on 23 September 2014).

6.27 BTEX compounds are not specifically banned in Western Australian petroleum legislation. The Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 provide that an EP for petroleum or geothermal activities must include details of chemicals or other substances ‘in, or added to, any treatment fluids to be used for the purposes of drilling or hydraulic fracturing’ or ‘otherwise introduced into a well.’²⁹⁶ There is no explicit reference to BTEX chemicals being restricted.

Finding 25: The Committee finds that the use of benzene, toluene, ethylbenzene and xylene during hydraulic fracturing poses an unacceptable and unnecessary risk to the environment and to human health.

Recommendation 7: The Committee recommends that the Government ban the use of benzene, toluene, ethylbenzene and xylene during any hydraulic fracturing operations undertaken in Western Australia.

²⁹³ F Leusch & M Bartkow, *A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids*, Griffith University Smart Water Research Centre, 17 November 2010, p 2.

²⁹⁴ Section 206 of the Queensland statute provides that an environmental authority (licence) ‘is taken to include a condition prohibiting the use of restricted stimulation fluids’. ‘Restricted stimulation fluids’ are then defined in that same section to include BTEX compounds or chemicals that ‘produce, or are likely to produce’ BTEX compounds as the chemical breaks down in the environment: s 206(4).

²⁹⁵ First issued in 2012, currently subject to review and available at: <http://www.trade.nsw.gov.au/policies/items/ban-on-use-of-btex-compounds-in-csg-activities>.

²⁹⁶ Petroleum and Geothermal Energy Resources (Environment) Regulations 2012 r 15. Environment plans must include an implementation strategy which, amongst other things, includes the details of chemicals used during hydraulic fracturing operations.

INNOVATION IN CHEMICALS

6.28 Technology as lucrative and expensive as hydraulic fracturing for unconventional gas inevitably leads to scientific innovation and development. The Committee has heard of advances in chemicals in use, such as Halliburton's 'CleanStimAUS' fluid system, made entirely from 'ingredients sourced from the food industry.'²⁹⁷ Halliburton Australia also advised that it invests significantly in research and development, with its 2012 research and development expenditure totalling \$460 million in Australia.²⁹⁸

6.29 Industry can be reticent to disclose the details of chemicals used during its hydraulic fracturing operations. Santos Limited advised the Committee that:

*A potential unforeseen outcome of full disclosure, including constituent hydraulic fracturing fluid recipes, is that new, innovative and more environmentally benign products may not be used, with companies only having available older and less beneficial alternatives.*²⁹⁹

6.30 The Committee has been informed by international regulators that the reality in the unconventional gas industry is that when new technology is developed, the nature of the trade is such that news will spread quickly and similar products will be developed.

6.31 The Committee notes that, where it can help allay the fears of the community, publicising innovations in chemical use may be of more benefit to industry than closely guarding its proprietary secrets.

DISCLOSURE VERSUS INTELLECTUAL PROPERTY CONCERNS

6.32 The Committee is of the view that the perceived secrecy surrounding the details of chemicals used by companies during hydraulic fracturing operations is a very important issue in the community and must be addressed.

6.33 The example often cited from the USA is that of the 'Halliburton Loophole', where amendments in 2005 to federal water legislation exempted exploration companies from the compulsory disclosure of the chemicals used in hydraulic fracturing operations.³⁰⁰ The Committee notes that the issues of secrecy around chemical use and

²⁹⁷ Submission 106 from Halliburton Australia Pty Ltd, 4 October 2013, p 5. The Committee notes that Halliburton's CleanStim website contains a disclaimer that 'though all the ingredients are acquired from food suppliers, the CleanStim fluid system should not be considered edible.' Available at: <http://www.halliburton.com/en-US/ps/stimulation/fracturing/cleanstim-hydraulic-fracturing-fluid-system.page>. Viewed 2 June 2015.

²⁹⁸ Submission 106 from Halliburton Australia Pty Ltd, 4 October 2013, p 5.

²⁹⁹ Submission 109 from Santos Ltd, 4 October 2013, p 10.

³⁰⁰ For further discussion, see: G Zuckerman, *The Frackers: the outrageous inside story of the new energy revolution*, Portfolio Penguin, London, 2013; A Prud'Homme, *Hydrofracking: what everyone needs to know*, Oxford University Press, Oxford, 2014; R Heinberg, *Snake Oil: How Fracking's False Promise of Plenty Imperils Our Future*, Post Carbon Institute, Santa Rosa, 2013.

a social licence to operate are closely linked and the decision to not fully disclose on the grounds of intellectual property concerns may harm a company's standing in the community (see CHAPTER 10).

6.34 DMP has advised that all petroleum activities, including hydraulic fracturing for unconventional gas, must receive the department's approval and are subject to legislative reporting requirements. Other disclosure requirements include:

- submitting particulars of drilling fluids as part of the application to drill (clause 8, Schedule 1 of the PGER Regulations)
- information relating to fluids used is required as part of the Well Completion Plan (regulation 74 and Schedules 8 and 9 of the PGER Regulations)
- for any approved petroleum activities, a summary version of the approved EP, including all chemicals likely to be used, is publicly disclosed on DMP's website.³⁰¹

6.35 DMP has also advised the Committee that:

DMP approves the use of all chemicals to be used for drilling, cementing and hydraulic fracturing and these are publicly disclosed. All chemicals must have a Chemical Abstract Service (CAS) number – a code unique to each chemical. This effectively limits the use of 'proprietary' and 'commercial-in-confidence' chemicals.³⁰²

6.36 At a hearing, the Committee explored DMP's public disclosure of chemicals further:

Hon Paul BROWN: *Just to clarify, all chemicals will be publicly available.*

Ms Andrews: *Yes.*

Mr Sellers: *Are.*

Hon PAUL BROWN: *...We have the confidence here to be able to say, through our report and publicly, that all chemicals are publicly disclosable. We are not necessarily worried about the recipe, but all ingredients are publicly available, not just to the DMP, but also to the public at large.*

³⁰¹ Letter from Hon Bill Marmion MLA, Minister for Mines and Petroleum, 14 April 2015, p 2.

³⁰² Ibid, p 4.

*Mr Sellers: That is right.*³⁰³

Hon STEPHEN DAWSON: ...but the regulations stipulate chemical disclosure to the department. They do not stipulate public disclosure to the community, do they?

*Mr Sellers: Certainly, that is the intent and that is what we do.*³⁰⁴

- 6.37 DMP has advised the Committee that the ‘system-based’ chemical disclosure that it advocates ‘allows public disclosure of all chemicals while providing some form of protection of manufacturer’s products.’³⁰⁵ However, system-based disclosure is to DMP only, not to the public: DMP advises that this enables disclosure ‘without compromising commercially sensitive information about product recipes.’³⁰⁶
- 6.38 Chemical disclosure information must also be submitted to DMP as part of the summary EP, which is then made publicly available by DMP.³⁰⁷
- 6.39 The Committee is of the view that this qualified disclosure may not allay the community’s concerns regarding the specific chemicals used during the hydraulic fracturing process.

Finding 26: The Committee finds that the perceived secrecy surrounding the details of chemicals used by resource companies during hydraulic fracturing operations is a very important issue in the community and must be addressed.

Recommendation 8: The Committee recommends that the Department of Mines and Petroleum’s policy of public disclosure of chemicals used in any hydraulic fracturing activity be formalised in subsidiary legislation.

- 6.40 The Committee also received submissions from industry groups and companies, many of which support the full disclosure of hydraulic fracturing chemicals to regulators and

³⁰³ Hon Paul Brown, Member, Ms Michelle Andrews, Deputy Director General, Department of Mines and Petroleum and Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 6.

³⁰⁴ Hon Stephen Dawson, Deputy Chair and Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 7.

³⁰⁵ Letter from Hon Bill Marmion MLA, Minister for Mines and Petroleum, 14 April 2015, p 4.

³⁰⁶ Submission 105 from Department of Mines and Petroleum, 3 October 2013, p 11. 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).

³⁰⁷ Letter from Mr Richard Sellers, Director General, Department of Mines and Petroleum, 8 September 2015, p 2.

to the public.³⁰⁸ Other stakeholders submitted that chemical disclosure should, in fact, be qualified. For example:

- Halliburton Australia offers two alternatives to full public disclosure: a system that provides for the ‘disclosure of hydraulic fracturing ingredients and maximum concentrations on a well-by-well basis to the public’; or, providing full disclosure only to the federal National Industrial Chemicals Notification and Assessment Scheme (see paragraph 4.121) with proprietary information being ‘protected from public release.’³⁰⁹ Halliburton Australia also supports chemical disclosure through FracFocus (see paragraph 6.42).
- Santos Limited supports public disclosure through FracFocus, but also believes that full disclosure of some chemicals used in hydraulic fracturing should be protected as proprietary information. Santos Limited submitted that a potential unforeseen outcome of full disclosure is that ‘new, innovative and environmentally benign products may not be used.’³¹⁰
- AWE Limited is concerned that DMP’s updated guidelines for the disclosure of chemicals may lead to issues related to intellectual property rights. AWE Limited submitted that some third party contractors may withhold their products from the Western Australian hydraulic fracturing market due to sensitivities surrounding the release of chemical compounds.³¹¹

6.41 APPEA submitted its Code of Practice for Hydraulic Fracturing (see paragraph 5.17).³¹² The Code requires that operators support the public release of chemical information, subject only to the protection that NICNAS provides for commercially sensitive information (see paragraph 4.121).

FracFocus

6.42 FracFocus is an online chemical registry (accessed via fracfocus.org) managed by two organisations in the USA: the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission. FracFocus deals only with issues related to chemical use during hydraulic fracturing (for example, it does not provide information related to NORM).

³⁰⁸ For example, Submission 78 from Tamboran Resources, 20 September 2013 and Submission 112 from Chamber of Minerals and Energy of Western Australia, 7 October 2013.

³⁰⁹ Submission 106 from Halliburton Australia Pty Ltd, 4 October 2013, pp 4-5.

³¹⁰ Submission 109 from Santos Limited, 7 October 2013, p 10.

³¹¹ Submission 113 from AWE Limited, 7 October 2013, p 25.

³¹² Submission 104 from Australian Petroleum Production and Exploration Association, 3 October 2013, Appendix 3.

- 6.43 The primary purpose of the FracFocus online database is ‘to provide factual information concerning hydraulic fracturing and groundwater protection’ and is ‘not intended to argue either for or against the use of hydraulic fracturing as a technology.’³¹³
- 6.44 The Committee understands that 23 state regulators in the USA use FracFocus as a means of official state chemical disclosure: see **Figure 21**. FracFocus cannot enforce the regulatory regimes of its participating states. The Committee is of the view that it is nonetheless a useful tool by which state regulators can access chemical information provided by companies.

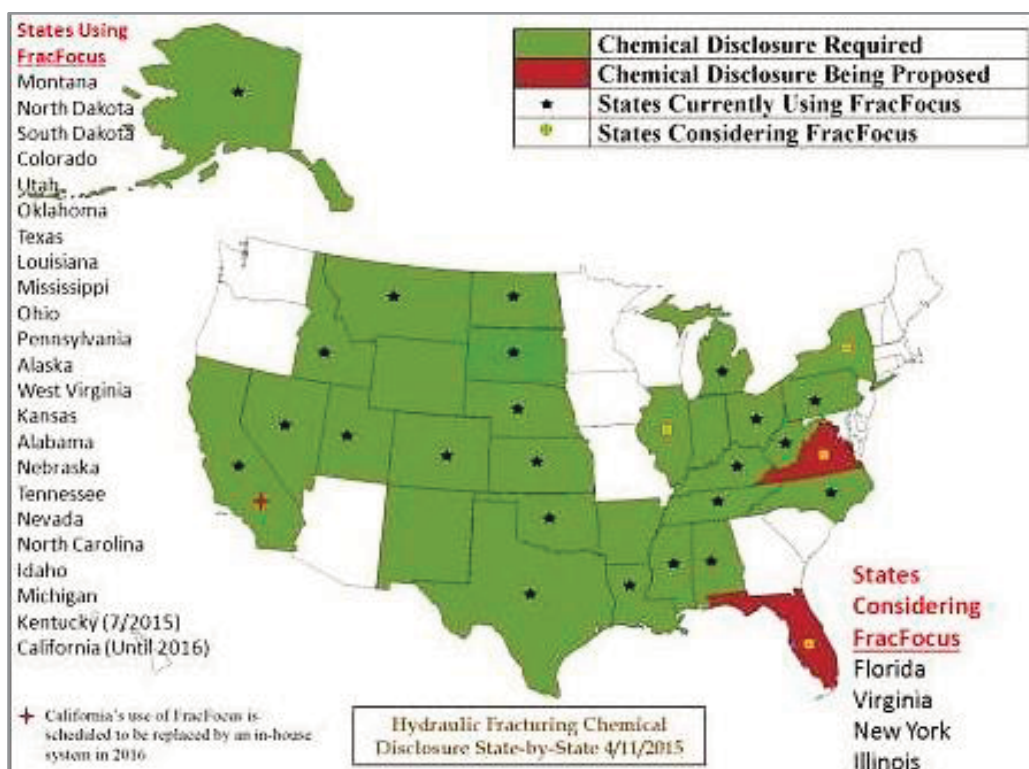


Figure 21. Hydraulic Fracturing Chemical Disclosure State-by-State as at 11 April 2015 [Source: [FracFocus.org](http://fracfocus.org)]

- 6.45 A state that publishes chemical information on FracFocus provides the following information:
- The date that the hydraulic fracturing occurred.
 - The name of the county and the state where the surface of the well is located.³¹⁴

³¹³ FracFocus, *About Us*. Available at: <http://fracfocus.org/welcome>. Viewed 2 June 2015.

³¹⁴ This can be significant if a horizontal well crosses underneath state boundaries.

-
- Details regarding the well, including the American Petroleum Institute number, operator name, well name and coordinates of the well, as well as total vertical depth of the well.
 - Total volume of water used as the carrier fluid for the fracturing.
 - Details regarding the chemicals used, including: trade names, supplier, purpose, ingredients (that is, the scientific name of the chemical), Chemical Abstract Service number, percentage mass of the ingredient within the additive and percentage mass of the ingredient as a per cent of the total hydraulic fracturing fluid.
- 6.46 As hydraulic fracturing is regulated on a state level in the USA, FracFocus publishes its information on wells according to each state's disclosure legislation and provides links to state regulators and statutes.³¹⁵
- 6.47 The website's 'Find a Well' functionality allows users to search for wells that have been hydraulically fractured in their own state, as specific as a particular well in their named county. An interested member of the public can learn the exact location of a well, all of the chemicals used in that well and how many gallons of water were used to fracture the well.
- 6.48 The Committee is not aware of any similar database provided in Western Australia to search specifically for details of the chemicals used during hydraulic fracturing for a specific well.

³¹⁵ FracFocus, *Regulations By State*. Available at: <http://fracfocus.org/regulations-state>. Viewed 3 June 2015.

CHAPTER 7

IMPACT OF HYDRAULIC FRACTURING ON WATER SOURCES

The impacts of shale gas extraction on water are likely to be local and dependent on whether the geographical location of any productive areas of geology coincide with areas of particular water resource pressure, or are near to groundwater resources or sensitive aquatic environments.

Chartered Institution of Water and Environmental Management,
*Shale Gas and Water: an independent review of shale gas exploration and exploitation in the UK with a particular focus on the implications for the water environment*³¹⁶

- 7.1 The protection of Western Australia's groundwater sources is one of the most important issues raised by the community. Western Australians are concerned about the impact of hydraulic fracturing on the State's water supplies. Examples of the community's concerns include:

*Groundwater is declining in the Midwest because of climate change and a drier climate.*³¹⁷

*Access to clean, safe water is a basic human right...The water table has already been impacted by mining in the Midwest and waterholes have gone dry.*³¹⁸

*Once the ground and the water beneath it is poisoned, it is for all time, affecting not only increasing population and its requirement for drinking water, but also the means by which to feed us.*³¹⁹

*I do not believe we should allow fracking to take place in Western Australia...I believe the aquifers are too important to risk.*³²⁰

- 7.2 The large volumes of water used and the potential for contamination of groundwater sources are key issues in relation to the implications for Western Australia of hydraulic fracturing for unconventional gas.

³¹⁶ Chartered Institution of Water and Environmental Management, *Shale Gas and Water: an independent review of shale gas exploration and exploitation in the UK with a particular focus on the implications for the water environment*, January 2014, p 26.

³¹⁷ Submission 31 from Nathalie Haymann, 18 September 2013.

³¹⁸ Submission 83 from Ronda Harman, 20 September 2013.

³¹⁹ Submission 32 from Sandra Reed and Nigel Rice, 18 September 2013.

³²⁰ Submission 53 from Dan Clarke, 19 September 2013.

7.3 Western Australia is a vast and arid state with limited underground water supplies. **Figure 22** illustrates the aquifers that exist across Australia. Most of Australia’s aquifers occur at shallow depths (for example, the Gnangara Mound is approximately 300 metres below the surface), compared to shale gas which is usually found at depths of several thousand metres (see paragraph 3.16).

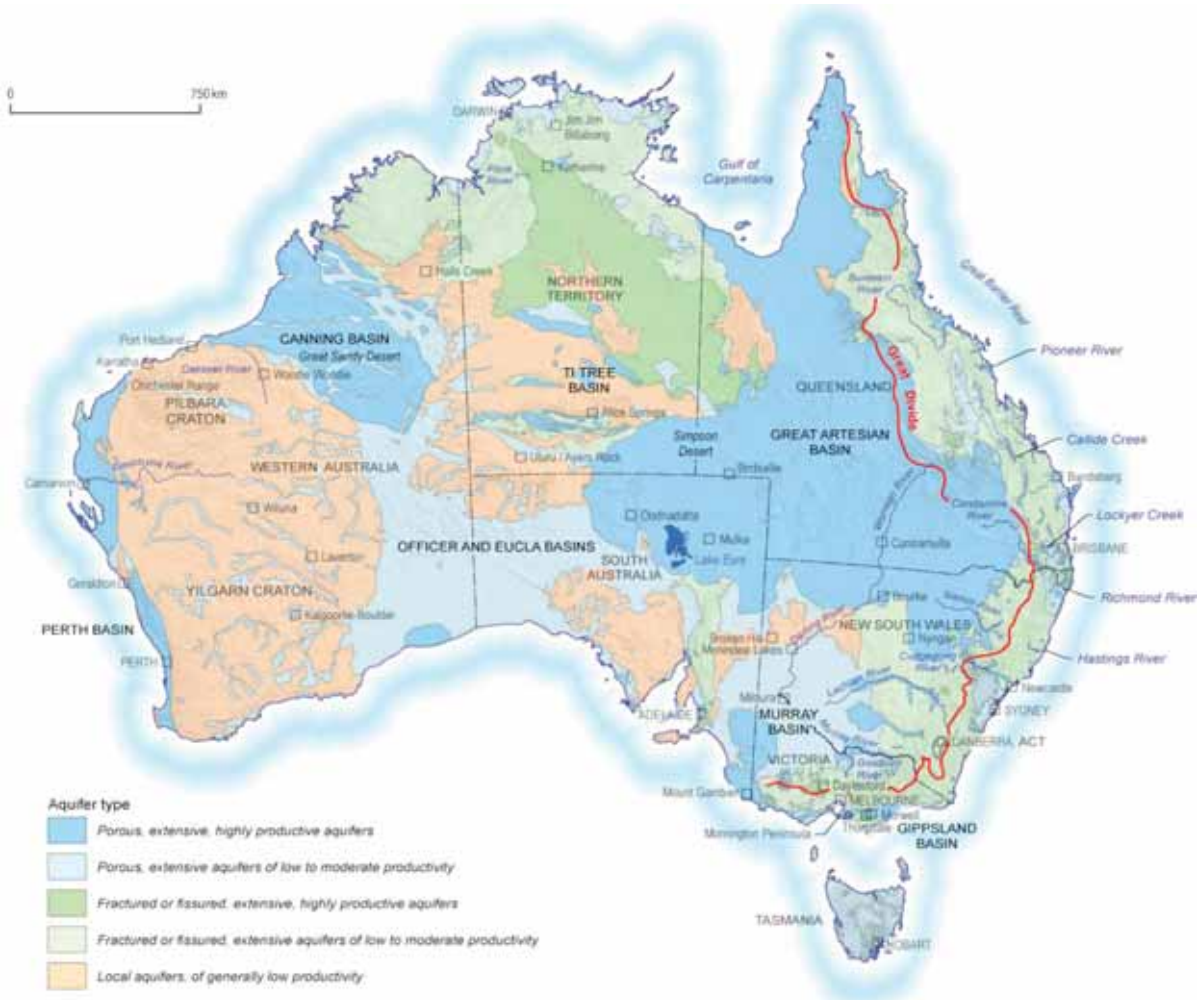


Figure 22. National Hydrogeological Map of Australia, showing the type and productivity of the principal aquifer and the linkage with regional geology [Source: Shaping a Nation: A Geology of Australia, Geoscience Australia, courtesy of Jacobsen & Lau, 1987]

7.4 The areas where unconventional gas is found in Western Australia (that is, the Canning, Perth and Carnarvon Basins) are ‘generally well below aquifers that are currently used for water production or are likely to be used in the future.’³²¹

WESTERN AUSTRALIA’S ARID CLIMATE AND WATER USE

7.5 Australia is the second driest continent in the world³²² and most of Western Australia is classified as either arid or semi-arid. The State’s dry climate means that there is

³²¹ Submission 115 from Department of Water, 15 October 2013, p 1.

potential for the large scale development of a shale gas industry to exacerbate the strain on water supplies. Similarly to climate pressures in Queensland and in Texas, USA, Western Australia has low average annual rainfall and relies mainly on groundwater to supply households and industry.

7.6 Western Australia has the highest rate of household water consumption per capita in Australia, on par with the Northern Territory.³²³ Household use, agricultural and mining water use all combine to account for two-thirds (67 per cent) of Western Australia's total water consumption (the remaining 33 per cent comprises manufacturing, electricity and industry, water supply and other industries). In comparison, the agriculture industry accounts for 65 per cent of Australia's total water consumption while mining only represented three per cent of the country's water use in 2012-13.³²⁴

7.7 Many countries with shale gas resources have limited supplies of fresh water and face 'water stress.'³²⁵ The World Resources Institute defines water stress as:

*the ratio of total water withdrawals from municipal, industrial and agricultural users relative to the available renewable surface water and higher values may indicate more competition among users and greater depletion of water resources.*³²⁶

7.8 The World Resources Institute found that, globally:

- 38 per cent of shale resources in the world are in areas that are either 'arid or under high to extremely high levels of water stress'
- 19 per cent are in areas of 'high or extremely high seasonal variability'
- 15 per cent are in locations exposed to 'high or extremely high drought severity.'³²⁷

7.9 A total of 386 million people live on the land over these shale plays and eight of the top 20 countries with significant shale gas resources face arid conditions of high or

³²² Second only to Antarctica.

³²³ 132 kilolitres per person: Australian Bureau of Statistics, *4610.0 Water Account Australia 2012-13*, 27 November 2014.

³²⁴ Ibid.

³²⁵ World Resources Institute, *Global Shale Gas Development: Water Availability and Business Risks*, Washington, 9 September 2014, p v.

³²⁶ Ibid, p 3.

³²⁷ Ibid, p 6.

extremely high water stress³²⁸ (see **Appendix 13**). Australia is classified as facing only a low level of water stress (see **Figure 23**) based on the fact that most of our shale gas resources are located in arid areas (such as the Cooper Basin in South Australia and the Canning Basin in the Kimberley).

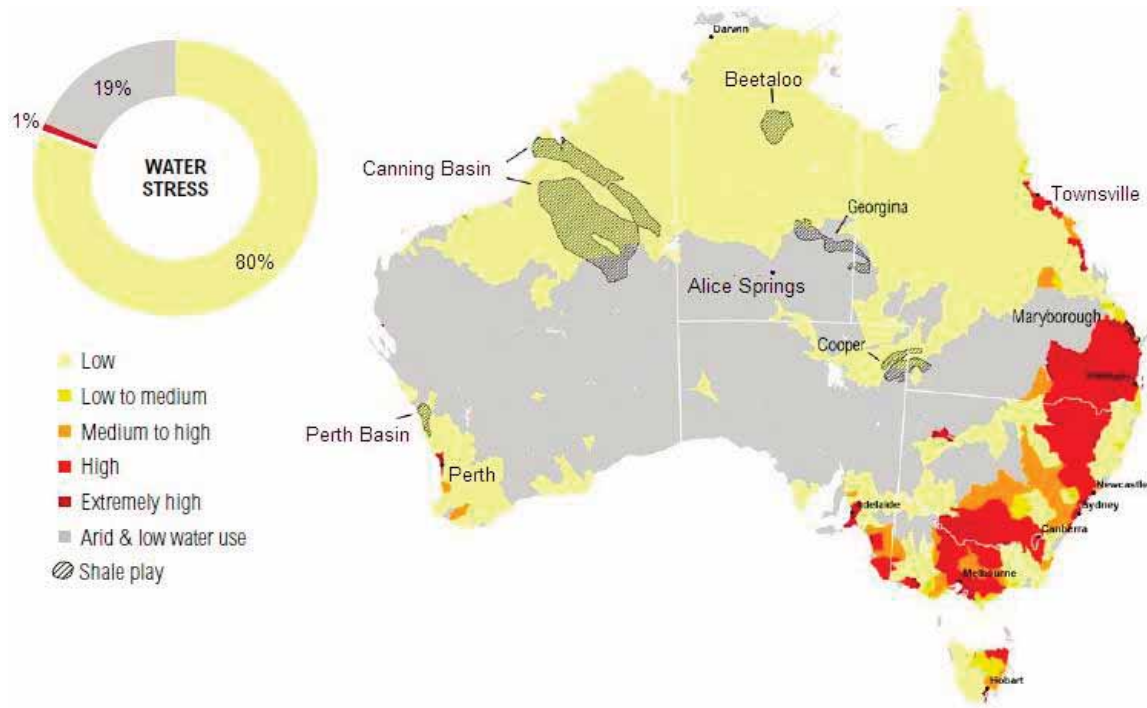


Figure 23. Shale Plays and Baseline Water Stress in Australia [Source: World Resources Institute report, 2014]

WHEN WATER IS USED IN HYDRAULIC FRACTURING

7.10 Water is a major component of nearly all hydraulic fracturing operations involving unconventional gas, but much more so with shale gas than CSG. The use of water during hydraulic fracturing depends on many variables, including the stage of drilling, the size and length of a well and the properties of the rocks that are to be fractured.³²⁹ The extraction of water (and subsequent disposal) is therefore a crucial part of the regulatory regime as it can have a lasting impact on water supplies.

7.11 Water is generally required at the outset of a hydraulic fracturing operation (in stages) and often in large quantities in a short period of time. Most of the water currently used for petroleum activities (conventional or unconventional) in Western Australia is

³²⁸ World Resources Institute, *Global Shale Gas Development: Water Availability and Business Risks*, Washington, 9 September 2014, p 6.

³²⁹ Submission 115 from Department of Water, 15 October 2013, p 1.

taken from underground aquifers.³³⁰ Water that is used to fracture unconventional gas formations does not need to be potable.³³¹

REGULATION OF THE TAKING OF WATER IN WESTERN AUSTRALIA

- 7.12 The water extraction licensing regime is complex in its application, involving the interaction of several Acts and instruments of subsidiary legislation.³³²
- 7.13 DoW issues licences for the taking of water (including for hydraulic fracturing) pursuant to the RIWI Act, but is involved in the management of the water resource at the extraction point only: DoW is not involved in further management of the activity that the water will subsequently be used for.³³³ The injection of water or fluids into the ground for hydraulic fracturing activities is regulated by DMP under the PGERA, always within the broader scope of activities which are deemed compatible with PDWSA in DoW's LUCT³³⁴ (see paragraph 4.95).
- 7.14 DoW advised at a hearing that:

Mr Bagdon: We license the take of water from declared water resources, so we do not regulate what happens around those water resources but, rather, we regulate the management of the water resource itself...we license the construction of the wells and we license the conditions under which they may actually abstract water from that resource.

The CHAIRMAN: This is the point of ambiguity: I understand from your submission that all wells and bores in proclaimed groundwater areas have to be licensed.

Mr Bagdon: That is wells for the taking of water. The wells used for petroleum exploration and subsequently fracking are not the taking of water. They pass through the aquifer; they do not actually take water from the aquifer. If, for the purposes of drilling, they wish to take

³³⁰ Submission 103 from Department of Mines and Petroleum, 3 October 2013, p 13 and Submission 115 from Department of Water, 15 October 2013, p 1.

³³¹ Ibid, p 1.

³³² This includes the *Rights in Water and Irrigation Act 1914*, *Country Areas Supply Act 1947*, *Metropolitan Water Supply, Sewerage and Drainage Act 1909* and associated subsidiary legislation.

³³³ Mr Tadas Bagdon, Executive Director Policy and Innovation, Department of Water, *Transcript of Evidence*, 7 February 2014, p 10.

³³⁴ Submission 115 from Department of Water, 15 October 2013, p 5.

*water, we would be involved in the assessment and licensing of that take but not of a well for petroleum exploration.*³³⁵

- 7.15 DoW does, however, provide guidance to resource companies on the management of water that is used during mining, including the following objectives:
- to ensure that fit-for-purpose water is used wherever possible and high quality water is used only in situations where it is essential or no other suitable water is available and with the fewest adverse effects
 - to maximise water use efficiency at all mine sites, particularly water deficient sites, to reduce the need for water to be abstracted from the environment
 - to ensure that mining activity does not adversely affect the quality and quantity of public and private drinking water supplies
 - to ensure that the cumulative effects of mining operations are considered and managed.³³⁶

Proclamations

- 7.16 Whilst most of Western Australia is proclaimed as surface or groundwater areas (approximately 90 per cent of the State), only a small percentage of the State is further set aside as PDWSA (less than one per cent).³³⁷
- 7.17 The power in the RIWI Act to proclaim an area of surface or groundwater gives the Minister of Water and DoW the power to actively manage the particular area through the licensing regime set out in the RIWI Act (see paragraph 7.19).
- 7.18 If the Minister for Water determines that a public drinking water source requires further protection, that PDWSA may be proclaimed as a water reserve, catchment area or underground water pollution control area according to the powers in the *Country Areas Water Supply Act 1947* and the *Metropolitan Water Supply, Sewerage and Drainage Act 1909*, respectively. Such a proclamation ensures that DoW can manage the drinking water quality of the proclaimed area by regulating land use and certain activities in the PDWSA.³³⁸ DoW may assign one of three different priority areas to land within the PDWSA (P1, P2 or P3: see paragraph 4.96) depending upon the level of protection that the source area requires.

³³⁵ Hon Simon O'Brien, Chairman and Mr Tadas Bagdon, Executive Director Policy and Innovation, Department of Water, *Transcript of Evidence*, 7 February 2014, p 2.

³³⁶ Department of Water, *Western Australian water in mining guideline: Water licensing delivery series Report No. 12*, May 2013, p 1.

³³⁷ Mr Tadas Bagdon, Executive Director Policy and Innovation, Department of Water, *Transcript of Evidence*, 7 February 2014, p 3 and Submission 47 from Water Corporation, 20 September 2013, p 3.

³³⁸ Letter from Hon Mia Davies MLA, Minister for Water, 26 August 2015, p 2.

Licensing

7.19 DoW regulates groundwater areas within Western Australia using the RIWI Act as follows:

- when a well or a bore (artesian or non-artesian) is constructed within a proclaimed area, a licence is required: section 26A
- when access to water from a proclaimed area is required (the ‘taking’ of water), a licence is also required: section 5C.³³⁹

7.20 The grant of a licence for access to a proclaimed water source under the RIWI Act is at the discretion of DoW, as the delegate for the Minister for Water. In exercising that discretion, DoW must consider the factors set out in clause 7 of Schedule 1 of the RIWI Act. There are 13 factors set out in Schedule 1, clause 7 that DoW must have regard to when exercising the discretion to grant a licence, such as whether the proposed taking and use of water:

(a) are in the public interest; or

(b) are ecologically sustainable; or

(c) are environmentally acceptable; or

(d) may prejudice other current and future needs for water; or

(e) would, in the opinion of the Minister, have a detrimental effect on another person; or

(f) could be provided for by another source; or

(g) are in keeping with –

(i) local practices; or

(ii) a relevant local by-law; or

(iii) a plan approved under Part III Division 3D Subdivision 2; or

(iv) relevant previous decisions of the Minister;

or

³³⁹ Submission 115 from Department of Water, 15 October 2013, pp 3-4. A permit may also be required for interfering with a watercourse’s ‘bed or banks’: RIWI Act ss 11, 17 and 21A.

(h) are consistent with –

(i) land use planning instruments; or

(ii) the requirements and policies of other government agencies; or

(iii) any intergovernmental agreement or arrangement.

7.21 When a licence is granted by DoW, the conditions attached to the licence will reflect the likely risks and possible impacts associated with that taking of water, based on the factors in Schedule 1, clause 7.³⁴⁰ The factors listed in clause 7 of Schedule 1 of the RIWI Act are also used by DoW when it issues licences for the construction of wells and bores in proclaimed groundwater areas.

7.22 The Committee has confirmed with DoW that, as at 21 August 2015, DoW has not granted any licences for the taking or abstraction of water resources for use in drilling or hydraulic fracturing.³⁴¹

Penalties

7.23 The RIWI Act sets out penalties for the unauthorised well construction or taking of water from proclaimed groundwater source areas for example:

- taking water from any watercourse, wetland or underground water source without authorisation carries a \$10 000 penalty and a daily penalty of \$1000: section 5C(1)
- constructing an artesian or non-artesian well without a licence carries a \$10 000 penalty and a daily penalty of \$1000: sections 26A(2) and 26B(3)
- the improper use, waste or other degradation of water (including harmful effects or not using water to the best advantage) that is taken from any artesian or non-artesian well: non-compliance with a notice can result in a \$5000 penalty and \$500 daily penalty (section 26G(3)).³⁴²

7.24 DoW will initiate enforcement action commensurate with the risk to the resource if it finds that a licence holder has breached their licence conditions or the legislation.

³⁴⁰ Submission 115 from Department of Water, 15 October 2013, p 6.

³⁴¹ Updated information provided by Department of Water on 25 August 2015, based on: Answer to Question on Notice 1202 asked in the Legislative Council by Hon Lynn MacLaren and answered by Hon Ken Baston, *Parliamentary Debates (Hansard)*, 22 October 2014, p 25.

³⁴² For a full list of licensing and permit powers under the *Rights in Water and Irrigation Act 1914*, see Submission 115 from Department of Water, 15 October 2013, Attachment 1 on p 15.

Enforcement is not limited to financial penalties, such as those outlined above, but may also include prosecution, the cancellation or suspension of the licence.³⁴³

- 7.25 The level of compliance activity that DoW undertakes for hydraulic fracturing relates to whether the licence holder is complying with the conditions on the licence, rather than any additional scrutiny of hydraulic fracturing activities:

Mr Bagdon: It would be very similar to the compliance activities we would take for any licence in the sense that we would monitor the take and we would ensure that they were complying with any conditions that we put onto that licence.

Hon STEPHEN DAWSON: And if they were not complying with those conditions?

Mr Bagdon: We have a compliance regime whereby, first of all, we go through a series of steps and if those steps all fail, then we would seek prosecution.³⁴⁴

- 7.26 The RIWI Act contains numerous offences relating to water licensing, for example the following:

- the unauthorised taking of water without a right or licence (with a \$10 000 penalty and \$1000 daily penalty: section 5C)
- the unauthorised construction or alteration of a non-artesian well (with a \$10 000 penalty and \$1000 daily penalty: section 26B)
- the improper use, waste or other degradation of water (including harmful effects or not using water to the best advantage) that is taken from any artesian or non-artesian well: non-compliance with a notice can result in a \$5000 penalty and \$500 daily penalty (section 26G(3)).³⁴⁵

Reinjection of water

- 7.27 DoW advises that reinjection of produced water back into the shale play from where the gas was extracted does not present any additional risk to underground aquifers.³⁴⁶ However, reinjection of the produced water into an aquifer may adversely affect groundwater quality and DoW's position is that:

³⁴³ Submission 115 from Department of Water, 15 October 2013, p 7.

³⁴⁴ Hon Stephen Dawson, Deputy Chair and Mr Tadas Bagdon, Executive Director Policy and Innovation, Department of Water, *Transcript of Evidence*, 7 February 2014, p 5.

³⁴⁵ For a full list of licensing and permit powers under the *Rights in Water and Irrigation Act 1914*, see Submission 115 from Department of Water, 15 October 2013, Attachment 1 on p 15.

³⁴⁶ Submission 115 from Department of Water, 15 October 2013, p 11.

*any water injected into an aquifer must be of equal or better quality than the quality of the receiving groundwater.*³⁴⁷

- 7.28 The produced water to be reinjected into an aquifer must be treated prior to injection if it is not of the same quality as the aquifer to ensure that the aquifer's water quality is not compromised.

QUANTITY OF WATER USED IN THE HYDRAULIC FRACTURING PROCESS

- 7.29 The intensity and volume of water use is an impact that may make unconventional gas production 'costly and unsustainable' in many areas of the world that are water-constrained.³⁴⁸ There are significant differences between hydraulic fracturing for shale gas and for CSG; one of these is the amount of water that is required to extract shale gas:

*The volume of water required to hydraulically fracture shale gas strata can be an order of magnitude larger than that for coal seam gas depending on well depth and extent of horizontal drilling.*³⁴⁹

- 7.30 The Committee notes that the amount of water used during hydraulic fracturing can still be significantly less than that used by other industries, such as agriculture. The average amount of water for each hydraulic fracture has been estimated at 7000 kilolitres, whilst the average water allocation to irrigate a ten hectare vegetable crop in Western Australia for one year is up to 150 000 kilolitres (see **Figure 24**).

³⁴⁷ Submission 115 from Department of Water, 15 October 2013, p 11.

³⁴⁸ British Geological Survey, *Potential groundwater impact from exploitation of shale gas in the UK*, Groundwater Science Programme Open Report OR/12/001, 2012, p 8.

³⁴⁹ ACOLA Report, p 24.

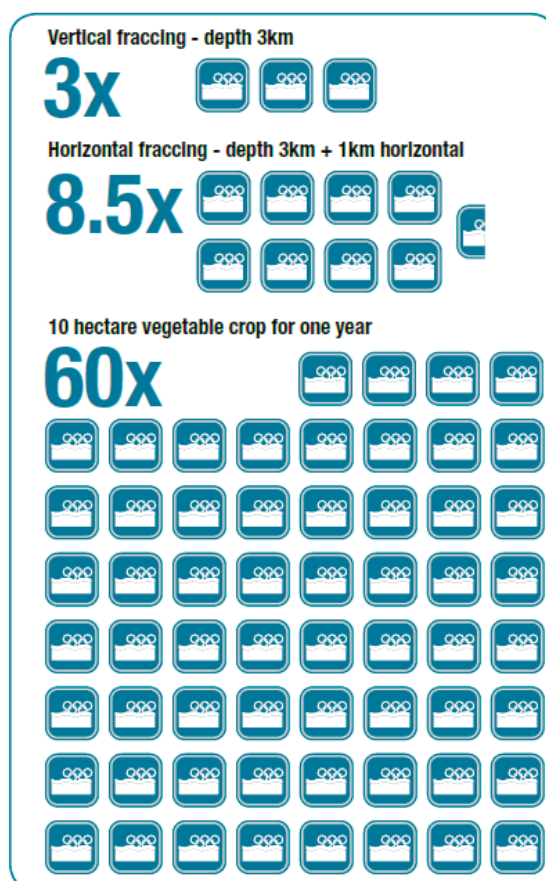


Figure 24. Comparison of water required to drill and fracture a vertical petroleum well, a horizontal well and the amount of water required to irrigate a 10 hectare vegetable crop in WA. Note that each graphic refers to an Olympic swimming pool for illustration [Source: Department of Mines and Petroleum fact sheet, September 2014]

- 7.31 Whilst DMP’s data above refers to the figure of 7000 kilolitres being used during hydraulic fracturing as a measure of comparison, the Committee notes that the data does not address the fact that wells are often fractured many times, thereby increasing the volume of water used substantially.

- 7.32 All of the shale gas wells drilled and completed in the USA in 2011 used 135 billion gallons (511 million kilolitres) of water in total, equivalent to 0.3 per cent of USA’s freshwater consumption, while agriculture used 32 840 billion gallons (124 000 million kilolitres) annually and golf courses used 0.5 per cent of freshwater supplies.³⁵⁰ High levels of water use can have an ongoing effect on water quality which is not limited to hydraulic fracturing’s water use:

ground water withdrawals exceeding natural recharge rates decrease water storage in aquifers, potentially mobilising contaminants or allowing the infiltration of lower quality water from the land surface

³⁵⁰ The Energy Collective, ‘Energy Facts: How Much Water Does Fracking for Shale Gas Consume?’, J Jenkins, 6 April 2013. Available at: <http://theenergycollective.com/jessejenkins/205481/friday-energy-facts-how-much-water-does-fracking-shale-gas-consume>. Viewed 19 September 2014.

or adjacent formations. Withdrawals could also decrease ground water discharge to streams, potentially affecting surface water quality.

Areas with large amounts of sustained ground water pumping are most likely to experience impacts, particularly drought-prone regions with limited ground water recharge.³⁵¹

RECYCLING OF PRODUCED WATER

- 7.33 The Committee has heard that water that is used during hydraulic fracturing does not need to be potable,³⁵² which raises the issue of recycling water for repeat use during drilling. Recycling for subsequent reuse during hydraulic fracturing is one of the methods that operators in the USA use to dispose of wastewater.³⁵³
- 7.34 In the USA, wastewater represents five per cent of the injected volumes of water used during hydraulic fracturing, with ‘the percentage varying by location.’³⁵⁴ For example, operators in Pennsylvania are larger users of reused wastewater than Texas: reused wastewater is approximately 18 per cent of injected volumes in the Marcellus Shale in Pennsylvania’s Susquehanna River Basin, compared to only five per cent in the Barnett Shale in Texas.
- 7.35 This data accords with the Committee’s own observations in Susquehanna County, Pennsylvania where operators are increasingly moving towards reuse of wastewater as a priority. The Committee notes that operators in the USA are exploring the technology of wastewater recycling voluntarily, without input from regulators.
- 7.36 Recycling wastewater brings financial benefits to operators in Pennsylvania, for example, where the cost of trucking wastewater to neighbouring Ohio for disposal far exceeds the cost of recycling onsite. There are also significant environmental benefits, such as minimising the amount of water used during the hydraulic fracturing process and decreasing road traffic. Operators in Texas, where much of the state faces drought (and therefore high water stress), are increasingly turning to recycling to reduce the impact of hydraulic fracturing on aquifers.³⁵⁵

³⁵¹ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, p 10.

³⁵² See footnote 331.

³⁵³ ‘Wastewater’ is defined in the USA Environmental Protection Authority’s report as including produced water and any other water generated at a hydraulic fracturing site.

³⁵⁴ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, p 7.

³⁵⁵ The Dallas Morning News, *Fracking companies begin slow shift to recycling wastewater*, 9 August 2014. Available at: <http://www.dallasnews.com/business/energy/20140809-fracking-companies-begin-slow-shift-to-recycling-wastewater.ece>. Viewed 20 August 2015.

7.37 **Figure 25** shows wastewater tanks in use in Pennsylvania, USA.



Figure 25. Cabot Oil and Gas Corporation holding tanks with wastewater to be reused for hydraulic fracturing, Susquehanna County, Pennsylvania, USA [Source: Committee site visit, 27 May 2014]

- 7.38 The reuse or disposal of produced water in Western Australia is the responsibility of DMP, pursuant to the PGERA: ‘DoW does not have legislative powers to regulate the reuse of produced water or the disposal of any wastewater.’³⁵⁶ In Western Australia, the Department of Environment Regulation and the EPA also have a role in the regulation of point source pollution and environmental impacts, respectively, but DoW provides advice only upon request.³⁵⁷
- 7.39 Recycling of produced water in Western Australia may be a viable alternative to using fresh water, but will be constrained by the cost of treatment and distribution and the remote locations of some shale gas plays in the State. The reinjection of produced water into shale plays is also an alternative disposal method. DoW advised that:

Reinjection of the produced water back into shale or tight gas horizons from where the gas was extracted does not present any additional risks to aquifers...On the other hand, reinjection of the produced water into aquifers may adversely affect the quality of the groundwater.

The DoW’s Operational Policy 1.01 Managed Aquifer Recharge in Western Australia...specifies that the DoW’s position is that any water injected into an aquifer must be of equal or better quality than

³⁵⁶ Submission 115 from Department of Water, 15 October 2013, p 10.

³⁵⁷ Ibid, p 10.

*the quality of the receiving groundwater. This would also apply to the injection or re-injection of fracking fluids into aquifers...*³⁵⁸

- 7.40 The potential impact of reinjecting produced water underground is discussed further in CHAPTER 9.

Finding 27: The Committee finds that there are significant environmental and financial benefits that may accrue to operators from the use of recycled wastewater during hydraulic fracturing.

Recommendation 9: The Committee recommends that resource companies in Western Australia be encouraged to explore the recycling of wastewater during hydraulic fracturing operations, where practicable.

- 7.41 The Committee notes that there are methods being researched in the USA to minimise the use of water during hydraulic fracturing. In Texas, for example, a state with similar water use concerns as Western Australia, companies are trialling the use of ‘water-free fracking’ during hydraulic fracturing operations.³⁵⁹
- 7.42 The technology, which can use substances such as propane, carbon dioxide or nitrogen is still in the early stages of development, but may be a way to reduce the impact upon water resources in the future. The use of water sourced from saline, non-potable aquifers is also an alternative to fresh water use that the Committee believes should be investigated further. In the USA, taking water from saline aquifers is common practice, as most shale plays in the USA have high salinity levels and the shales themselves are often of marine origin.³⁶⁰
- 7.43 Water that is sourced for use during hydraulic fracturing operations often has chemicals added to it so that its chemical composition more closely matches that of the shale formation to be drilled (that is, to become more brackish or saline). Using water from saline aquifers, therefore, may also reduce the amount of chemicals needed during drilling.
- 7.44 The use of saline aquifers during hydraulic fracturing operations merits further research and investigation as a means of reducing the potential impact of the process on drinking water sources.

³⁵⁸ Submission 115 from Department of Water, 15 October 2013, p 11.

³⁵⁹ K Gilbraith, *Waterless Fracking Makes Headway in Texas, Slowly*, StateImpact Texas, Texas Tribune, 27 March 2013. Available at: <http://stateimpact.npr.org/texas/2013/03/27/waterless-fracking-makes-headway-in-texas-slowly/>. Viewed 9 June 2015.

³⁶⁰ ACOLA Report, p 60.

Finding 28: The Committee finds that the Government should encourage resource companies to investigate alternatives to fresh water use during hydraulic fracturing, including the use of water from saline aquifers, with a view to reducing the reliance upon fresh water for hydraulic fracturing operations.

RISKS OF WATER CONTAMINATION AND POLLUTION DURING HYDRAULIC FRACTURING

7.45 The main concerns drawn to the Committee's attention in relation to groundwater and hydraulic fracturing are that it will adversely affect:

- drinking water supplies
- groundwater used for agricultural land
- surface water.

7.46 The USA Environmental Protection Authority has found that there is a risk for the contamination of drinking water sources if hydraulic fracturing is undertaken nearby:

*Although proximity of hydraulic fracturing activities to a drinking water resource is not in of itself sufficient for an impact to occur, it does increase the potential for impacts. Residents and drinking water resources in areas experiencing hydraulic fracturing activities are most likely to be affected by any potential impacts, should they occur.*³⁶¹ [Committee emphasis]

7.47 Contamination at a well site can occur as a result of many factors: the accidental leakage of fluids during drilling or production, well integrity failures, leakage along faults, surface spills, leakage from holding ponds or from pipes, or spills during the transport of fluid or chemicals (see **Figure 26**).³⁶²

³⁶¹ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, p 6.

³⁶² ACOLA Report, p 24.

# 1	Spill (20,600 litres) of a transport load of water without chemicals [1 in 50,000].
# 2	Spill (1,890 litres) of concentrated liquid biocide or inhibitor [1 in 4.5 million].
# 3	Spill (227 kg) of dry additive [1 in 4.5 million].
# 4	Spill (1,135 litres) of diesel from ruptured saddle tank on truck (road wreck) [1 in 5100].
# 5	Spill (13,250 litres) of fuel from standard field location refueler (road wreck) [1 in 1 million].
# 6	Spill (80,000 litres) of well-site water (salt/fresh) storage tank – no additives [1 in 1000].
# 7	Spill (190 litres) of water treated for bacteria control [1 in 10,000].
# 8	Spill (190 litres) of diesel while refuelling pumpers [1 in 10,000].
# 9	Spill (80,000 litres) of stored frack water backflow containing chemicals [1 in 1000].
# 10	Frack ruptures surface casing at exact depth of fresh water sand [1 in 100,000].
# 11	Frack water cooling pulls tubing out of packer, frac fluid in sealed annulus [1 in 1000].
# 12	Frack opens mud channel in cement on well less than 2000 feet deep [1 in 1000].
# 13	Frack opens mud channel in cement on well greater than 2000 feet deep [1 in 1000].
# 14	Frack intersects another frac or wellbore in a producing well [1 in 10,000].
# 15	Frack intersects an abandoned wellbore [1 in 500,000].
# 16	Frack to surface through the rock strata (well less than 2000 feet deep) [1 in 200,000].
# 17	Frack to surface through the rock strata (well greater than 2000 feet deep) [no cases].
# 18	'Felt' earthquake resulting from hydraulic fracturing [no cases in US].
# 19	Frack changes output of a natural seep at surface [1 in 1 million].
# 20	Emissions of methane, CO ₂ , NO _x , SO _x ... [high frequency].

Figure 26. Key risks for hydraulic fracturing and worst case frequency [Source: ACOLA Report 2013]³⁶³

7.48 Many of these risks are already part of the petroleum industry’s risk management regime, but there is a perception in the community that hydraulic fracturing increases either the severity or incidence of these risks.

7.49 There are several above and below ground mechanisms by which hydraulic fracturing can potentially impact drinking water resources. These risks include:

- Taking water in times of, or in areas with, low water availability (regulated through the grant of water taking licences: see paragraph 7.19).
- Spills of hydraulic fracturing fluids and produced water (see paragraph 7.54).
- Fractures intersecting with underground drinking water resources (see paragraphs 7.3 and 7.53).
- Below-ground migration of liquids and gases (see paragraph 7.58).
- Inadequate treatment and discharge of wastewater (see CHAPTER 8).³⁶⁴

³⁶³ The table in **Figure 26** is adapted from a study which assessed the worst case risk without the application of mitigating technologies: ACOLA Report, p 61.

³⁶⁴ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, p 6.

- 7.50 The Committee notes that there is no evidence that these risks have led to ‘widespread, systemic impacts on drinking water resources’ in the USA, but there were still ‘specific instances’ where contamination of drinking water wells occurred. According to the USA’s Environmental Protection Authority:

Impacts to drinking water resources from subsurface liquid and gas movement may occur if casing or cement are inadequately designed or constructed, or fail. There are several examples of these occurrences in hydraulically fractured wells that have or may have resulted in impacts to drinking water resources.

In one example, an inner string of casing burst during hydraulic fracturing, which resulted in a release of fluids on the land surface and possibly into the aquifer near Killdeer, North Dakota...In other examples, inadequately cemented casing has contributed to impacts to drinking water resources...construction issues, sustained casing pressure and the presence of natural faults and fractures can work together to create pathways for fluids to migrate toward drinking water resources.³⁶⁵

- 7.51 ACOLA recognises the need for baseline monitoring as part of an effective regulatory regime and also suggests that the risk of contamination of aquifers or surface water is low, provided that regulatory processes and monitoring are put in place and maintained.³⁶⁶

Fractures intersecting underground aquifers

- 7.52 The Committee notes that the distance between aquifers and the cracks in underground formations that are created by hydraulic fracturing is an essential factor in determining where to drill:

Vertical separation from aquifers and the nature of its intermediate formations are critical elements in designing the hydraulic fracturing events.³⁶⁷

- 7.53 Given that shale gas deposits are typically found at depths of more than 1500 metres below the surface and that the longest hydraulic fracture ever recorded is 588 metres

³⁶⁵ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, pp 14-15.

³⁶⁶ ACOLA Report, p 177.

³⁶⁷ *Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory*, Tabled Paper 1257. Also at <http://www.hydraulicfracturinginquiry.nt.gov.au/index.html>, p 74.

(less than one per cent extend to more than 500 metres³⁶⁸), the likelihood of a hydraulic fracture intersecting an aquifer is extremely remote.

Finding 29: The Committee finds that the likelihood of hydraulic fractures intersecting underground aquifers is negligible.

Spills

- 7.54 The impact of surface spills of fluids is often under-estimated as a source of water contamination during hydraulic fracturing operations. Surface spills of hydraulic fracturing fluid may pose a greater contamination risk than the process itself.³⁶⁹ Surface spills of produced water at the well or from trucks involved in the transport of fluids may also be a source of water contamination, depending on the volume of the spill, duration and the concentration of the fluid.³⁷⁰
- 7.55 There are, however, various techniques which operators may use to minimise the risks to surface water or underground water sources, including:
- Rigorous containment of fluid and solid chemicals (including the use of bunding in areas where chemicals are stored).
 - Robust procedures, training and availability of spill control equipment.
 - Greater use of pipelines to move liquids, rather than the use of trucks.³⁷¹
- 7.56 The IEA prefers the use of closed storage tanks instead of open pits for the storage of produced water onsite, as this can reduce the accidental discharge of waste water during operations.³⁷² If open pits are used, however, these must be constructed robustly and lined adequately to prevent spills to the environment from these storage areas.
- 7.57 The Committee notes that DMP closely monitors the risks associated with spills through its EP regime. Operators are required to submit details of their chemical storage procedures (including details of ponds/pits used and the level of bunding), personnel training and company spill response procedure and an operator's daily site

³⁶⁸ RJ Davies et al, 'Hydraulic fractures: How far can they go?', *Marine and Petroleum Geology*, vol 37, issue 1, November 2012, p 10.

³⁶⁹ Royal Society and Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 19.

³⁷⁰ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, p 19.

³⁷¹ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 37.

³⁷² Ibid, p 45.

inspection checklist must include the inspection of chemical storage areas.³⁷³ It is common practice for an EP to also include an operator's risk assessment, outlining all relevant risks, which would necessarily include an assessment of the risk of chemical or waste water spills.

Finding 30: The Committee finds that the risk of spills of chemicals or other fluids associated with hydraulic fracturing can be effectively managed in Western Australia through the environmental requirements in the Petroleum and Geothermal Resources (Environment) Regulations 2012.

Fugitive methane

- 7.58 Many of the community concerns that have been submitted to the Committee relate to methane that can escape from a gas well, thereby contaminating water sources or the atmosphere, known as 'fugitive methane.' The Committee notes the controversy created by the 2011 documentary 'Gasland,' specifically its focus on methane leaks from hydraulically fractured gas wells in the USA.³⁷⁴
- 7.59 Fugitive methane can lead to groundwater sources being at risk if methane migrates from the shale rock to surrounding aquifers following hydraulic fracturing. The Committee notes that leading research into fugitive methane suffers from a lack of comprehensive data and analysis of baseline measurements. There are also significant issues with the definition of 'well failure' and how methane leaks are defined (see CHAPTER 8).
- 7.60 The Committee has heard that methane can be naturally present in groundwater sources (called 'biogenic methane' or more colloquially, 'swamp gas') and that some existing water wells drilled in Dimock, Pennsylvania have historically been sources of biogenic methane, independent of any hydraulic fracturing in the area. Notwithstanding incidents of biogenic methane as described above, the Committee is also aware that there have also been cases in Pennsylvania where groundwater was contaminated as a likely result of methane escaping from hydraulically fractured gas wells.
- 7.61 In 2010 and 2011, residents living near Sugar Run, a stream in Pennsylvania, reported natural gas, sediment and white foam in their well water, following the drilling of five gas wells nearby.³⁷⁵ The Pennsylvania Department of Environmental Protection cited

³⁷³ Department of Mines and Petroleum, *Guidelines for the Preparation and Submission of an Environment Plan*, 28 August 2012, p 45.

³⁷⁴ 'Gasland', directed by Josh Fox, released in the USA in 2010.

³⁷⁵ Between 2009 and 2010, five gas well pads were constructed about 1 to 2.25 kilometres north of Sugar Run, where several private homes used groundwater for drinking purposes: GT Llewellyn et al, 'Evaluating a groundwater supply contamination incident attributed to Marcellus Shale gas development', *Proceedings of the National Academy of Sciences*, Vol. 112. No. 20, 19 May 2015, p 6326.

- the company responsible for the wells under Pennsylvanian legislation for allowing natural gas to enter aquifers. Researchers subsequently used baseline water samples from the residents' wells and advanced laboratory methods³⁷⁶ to conclude that 'the most likely explanation...is that stray natural gas and drilling or HF [hydraulic fracturing] compounds were driven ~1-3 km along shallow to intermediate depth fractures to the aquifer used as a potable water source.'³⁷⁷
- 7.62 The US Environmental Protection Authority also recently acknowledged that it had found 'specific instances' related to hydraulic fracturing that led to contamination of drinking water wells in the USA; the number of identified cases, however, 'was small compared to the number of hydraulically fractured wells' in total.³⁷⁸
- 7.63 ACOLA has identified that there needs to be more data gathered and analysed on the incidence of fugitive methane and more baseline data on biogenic methane in order to fully appreciate the potential risk to groundwater sources that hydraulic fracturing may present.³⁷⁹ Naturally-occurring 'methane seeps' have long been observed around the world (for example, the 'Eternal Flames Falls' in New York State, USA³⁸⁰) and demonstrate that not all methane found in water sources is linked to industrial contamination.³⁸¹
- 7.64 Understanding the natural sources of methane that may impact upon groundwater sources is essential to clarify the true impact that hydraulic fracturing may have on the environment:

Aside from emphasising the primary importance of well integrity, a key learning for the developing Australian shale gas industry from these debates is that resolving the source of methane (or other chemical) contamination of ground water in these contested areas was greatly hampered by a lack of comprehensive pre-drilling baseline water quality samples and studies.³⁸²

³⁷⁶ Techniques included '2D gas chromatography' and 'time-of-flight mass spectrometry (GCxGC-TOFMS)': GT Llewellyn et al, 'Evaluating a groundwater supply contamination incident attributed to Marcellus Shale gas development', *Proceedings of the National Academy of Sciences*, Vol. 112. No. 20, 19 May 2015, p 6327.

³⁷⁷ Ibid, p 6325.

³⁷⁸ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, p 23.

³⁷⁹ ACOLA Report, p 181.

³⁸⁰ Available at: <http://nyfalls.com/waterfalls/eternal-flame-falls/>. Viewed 9 July 2015.

³⁸¹ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 37.

³⁸² *Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory*, Tabled Paper 1257, p 90.

7.65 The Committee is of the view that the only way to conclude with certainty that hydraulic fracturing has resulted in contamination in a particular groundwater source is to have reliable baseline data that can be analysed in the unfortunate event of any contamination occurring. Methane in groundwater can occur as a result of natural geological processes; baseline data ensures accountability and provides certainty for the community that groundwater sources are adequately protected.

Finding 31: The Committee finds that the risk of water contamination as a result of fugitive methane during hydraulic fracturing in Western Australia is highly unlikely and can be minimised through baseline monitoring of water quality and ongoing monitoring pursuant to the Petroleum and Geothermal Energy Resources (Environment) Regulations 2012.

Finding 32: The Committee finds that the risk of fugitive methane relative to the total number of wells is very low and can be adequately managed.

Finding 33: The Committee finds that baseline water quality monitoring to measure any presence of methane in water sources is essential to ensure that water sources are protected from contamination.

Recommendation 10: The Committee recommends that baseline monitoring of aquifers and the subsequent publication of this data be a mandatory condition of all approvals for hydraulic fracturing operations in Western Australia.

CHAPTER 8

LEGACY OF HYDRAULIC FRACTURING ON LAND

The shale gas industry has the potential to impact on natural assets and the long-term function and value of vital renewable natural resource assets and ecosystem services. However the industry also has the opportunity to work with communities and regulators to minimise those potential impacts and maximise the prospect of positive outcomes.

Australian Council of Learned Academies³⁸³

- 8.1 Several members of the community submitted that the potential impact of hydraulic fracturing on land in Western Australia can continue long after a well has finished producing gas:

*I am concerned who has liability for abandoned sites after well abandonment, and what steps can be made to ensure that frackers don't just cut and run, leaving landholders and the community to deal with the consequences.*³⁸⁴

*Abandoned wells are not able to be secured in the long term and pose serious risks to water, soil and air over time.*³⁸⁵

*Any company who wants to mine must be held accountable to restore the area back to the condition they found it.*³⁸⁶

- 8.2 Through its inquiries, the Committee has come to the view that many of the concerns expressed by the community in relation to the impact of hydraulic fracturing for unconventional gas can be addressed through robust regulation and ongoing monitoring.
- 8.3 However, long term well integrity (including issues related to abandoned wells) is an area where further scientific study is needed to fully understand the potential implications of this industry on land.
- 8.4 The rehabilitation of land that was used for extracted unconventional gas is also an issue related to the ongoing legacy of mining on land.

³⁸³ ACOLA Report, p 109.

³⁸⁴ Submission 24 from Erica Brock, 18 September 2013, p 2.

³⁸⁵ Submission 28 from Patricia McAuliffe, 18 September 2013, p 24.

³⁸⁶ Submission 53 from Dan Clarke, 19 September 2013.

IMPACT OF UNCONVENTIONAL GAS OPERATIONS**Footprint of hydraulic fracturing during operations**

- 8.5 The impact of hydraulic fracturing for unconventional gas depends on the geology and geography of the area. This issue may also involve a value judgment for regulators and operators, as some might see no intrinsic value in arid, remote locations but these lands may be subject to native title interests which are significant to traditional owners (see CHAPTER 10).
- 8.6 Santos Limited submitted that the footprint of unconventional gas exploration changes over the lifetime of a project:

Mr Cruikshank: If we were in development mode, we would typically be using what we call multi-well pad technology, where instead of just drilling one well, we would be drilling six, eight, 10 or 12 wells. So, that minimises the land disturbance immediately. It also means that instead of having single wells where you have got one and a half hectares per well and a road and a pipeline et cetera, you have one road, one pipeline and you have got six, eight, 10, 12 or 15 wells et cetera. So, you are minimising the land disturbance on multiple counts already.

Once you have constructed the well and you have got the wells on production, we would then reclaim that lease pad back to probably something like a tenth of its size. So, it might start out at five or 10 hectares, depending on how many wells we are on that area for, and we would then bring that down to the minimum requirement for ongoing maintenance, surveillance and production activities. That would be done within probably 12 to 18 months of first starting until when we have finished what we call our well construction or development operations.

We would then reclaim back. That involves returning the land back to its natural contours, putting the topsoil back on that we have disturbed, reseeding it, and that would typically be probably reclaimed within months of us finishing an operation.

Then, whether it be for 10, 20, 30 or 40 years, we have that minimum area that we are working on. That would be in

*consultation with the landholder to ensure that that area is appropriate for what we are doing.*³⁸⁷

- 8.7 The Committee notes that the advancement of multi-well technology further decreases the surface impact of hydraulic fracturing on land (see paragraph 3.44). Horizontal drilling generally has a smaller footprint on land than vertical drilling, as a similar sized shale gas play could require between:
- 16 horizontal wells from a single pad of 2.5 hectares, with roads, pipelines and one processing facility connected to the pad (see **Figure 8**); or
 - 64 vertical wells on individual pads of 0.8 hectares each (totalling 50 hectares of land), plus road, pipeline and multiple processing facilities.³⁸⁸
- 8.8 Shale gas, however, will require an increasing number of wells to be drilled over the lifetime of production as recovery rates decrease, often exponentially.³⁸⁹
- 8.9 The visual impact of hydraulic fracturing also varies at the different stages of the process. Exploration may include conducting seismic surveys of the land, as illustrated in **Figure 27**, which can leave visible marks on the land and affect the natural vegetation, at least temporarily.



Figure 27. 3D seismic lines at Cooper Basin, South Australia – note undulating survey lines, rather than straight lines [Source: Committee site visit, 3 September 2014]

³⁸⁷ Mr Colin Cruikshank, General Manager Unconventional Resources and Exploration, Santos Ltd, *Transcript of Evidence*, 31 March 2014, p 11.

³⁸⁸ ACOLA Report, p 76.

³⁸⁹ *Ibid*, p 103.

- 8.10 Conversely, after production has finished, the visual impact of an unconventional gas well is reduced significantly and often requires only a Christmas tree installation on a much smaller area of land: see **Figure 28**.



Figure 28. Christmas tree at decommissioned Arrowsmith-02 well [Source: Committee site visit, 28 October 2014]

Number of wells needed

- 8.11 Drilling for hydrocarbons has a long history, but with sparse data available. In the USA alone, it has been estimated that at least 2.6 million hydrocarbon wells have been drilled since 1949.³⁹⁰ In the UK, 2152 onshore hydrocarbon wells were drilled between 1902 and 2013, with 1000 of those wells being drilled by companies that still exist today.³⁹¹
- 8.12 The Committee notes that there is an estimated total of at least four million onshore hydrocarbon wells, taking into consideration those wells drilled only in Australia, Austria, Bahrain, Brazil, Canada, the Netherlands, Poland, UK and USA.³⁹²
- 8.13 The Conservation Council of Western Australia (Inc.) submitted that the development of a commercial unconventional gas industry in Western Australia could result in ‘upwards of 100 000 wells’ in the Kimberley or ‘over 25 000 wells’ in the Midwest of

³⁹⁰ US Energy Information Administration, *Crude Oil and Natural Gas Exploratory and Development Wells*. Available at: http://www.eia.gov/dnav/ng/ng_enr_wellend_s1_m.htm. Viewed 4 June 2015.

³⁹¹ RJ Davies et al, ‘Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation’, *Marine and Petroleum Geology*, 2014, p9. Available at: <http://dx.doi.org/10.1016/j.marpetgeo.2014.03.001>. Viewed 4 June 2015.

³⁹² Ibid, p 5.

our State.³⁹³ The Committee has found no evidence to support this figure and believes that it is greatly over-stated. Nonetheless, the cumulative impact of the number of shale gas wells is an important factor in assessing the ongoing impact of hydraulic fracturing on land.

- 8.14 The USA's Environmental Protection Authority notes that the lack of effective monitoring and estimates of the number of wells makes it difficult to definitively assess the cumulative impacts of hydraulic fracturing. The Authority advises that the:

lack of a definitive well count particularly contributes to uncertainties regarding total water use or total wastewater volume estimates, and would limit any kind of cumulative impact assessment.

Lack of specific information about private drinking water well locations and the depths of drinking water resources in relation to hydraulically fractured rock formations and well construction features (eg, casing and cement) limits the ability to assess whether subsurface drinking water resources are isolated from hydraulically fractured oil and gas production wells.³⁹⁴

- 8.15 Due to the relatively under-developed nature of the unconventional gas industry in Western Australia, regulators and operators are in an ideal position to build upon the experience in the USA and develop a strong regulatory framework to deal with the issue of cumulative well impacts into the future.

Finding 34: The Committee finds that many of the concerns expressed by the community in relation to the impact of hydraulic fracturing for unconventional gas can be addressed through robust regulation and ongoing monitoring.

Finding 35: The Committee finds that the statement that the development of the unconventional gas industry in Western Australia will result in thousands of wells in the Kimberley and the Midwest has been over-stated and is not based on evidence.

Finding 36: The Committee finds that the cumulative impact of the number of shale gas wells is an important factor in assessing the ongoing impact of hydraulic fracturing on land.

³⁹³ Submission 110 from Conservation Council of Western Australia (Inc.), 4 October 2013, p 11.

³⁹⁴ United States Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, June 2015, p 23.

Importance of well integrity

- 8.16 Two of the most significant risks identified by both the Royal Society and Royal Academy of Engineering and ACOLA are the issues of well integrity (and associated methane leaks) and induced seismicity.³⁹⁵ Proponents and opponents both agree that the most important part of the hydraulic fracturing process is well integrity:

*The key to groundwater protection in oil and gas operations is well integrity. The proper construction of wells, using multiple layers of cemented steel casing, minimises any formation or well fluids' migration into drinking water aquifers.*³⁹⁶

*Since all fracking depends on cement to ensure well integrity, and isolation from aquifers, which often lie above shale seams, cement needs to be perfect, to ensure a perfect seal. It also needs to last for a very long time, even after the well has ceased production.*³⁹⁷

- 8.17 Wells may fail from poor well integrity that results from casing failure, inadequate cementation or, the most catastrophic event, a blowout.³⁹⁸ The community's concern about well integrity is that any one of these events could result in gas escaping the well and contaminating aquifers or causing explosions at the surface.

- 8.18 The Northern Territory Commissioner commented on well integrity's importance as follows:

*Ensuring well integrity presents a significant engineering and compliance challenge, with significant advances in leading practices during the past few decades as the shale gas industry developed. Many reported incidents that underlie public concern about ground water contamination may be linked to poor well construction techniques in the earlier stages of the unconventional gas and oil industry, and the risks are likely to be much lower for a developing industry in the NT using modern (and future) technology and subject to good regulatory practice.*³⁹⁹

³⁹⁵ Royal Society and Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p4 and ACOLA Report, p 71.

³⁹⁶ Mr David Guglielmo, Country Manager, Halliburton Australia Pty Ltd, *Transcript of Evidence*, 10 February 2014, p 2.

³⁹⁷ Submission 43 from Sven Borg, 18 September 2013, p 16.

³⁹⁸ Royal Society and Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 24. Blowouts are rare and even though shales can be over-pressurised, shale has very low permeability, making blowouts even more unlikely.

³⁹⁹ *Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory*, Tabled Paper 1257, 27 February 2015, p 85.

Monitoring well failures

- 8.19 In the course of its inquiries, the Committee has discovered that the term ‘well failure’ has different meanings according to different stakeholders. A well failure can range from an external valve or seal needing replacement through to a blowout (one of the most catastrophic events that can occur in the resource industry and may result in devastating damage and the loss of life).
- 8.20 The Committee therefore proceeds with a note of caution in its discussion of the rates of well failure in this chapter. This area of research is evolving and there is a lack of consensus as to the precise definition of what may constitute a well failure.

Finding 37: The Committee finds that it is important to recognise that there is mistrust and confusion in the community due to the different definitions of well failure.

- 8.21 The Committee has relied upon the definition of well integrity used by DMP in its capacity as lead regulator of unconventional gas in Western Australia.
- 8.22 DMP considers well integrity to have failed as soon as one of the barriers that separates a well from the environment has been breached and requires remedial action. The principle of having at least two barriers between the interior of the well and the subsurface environment is ‘an established standard to keep wells safe in all phases of their development.’⁴⁰⁰ A ‘leak path’ to the external environment does not occur therefore until both of those layers of casing in the well (the barrier) have failed.
- 8.23 The Committee therefore notes the distinction between a well integrity incident and the more serious situation where a well fails and a leak path to the environment is created. These two concepts are often conflated when considering the risks that hydraulic fracturing may pose to the environment.
- 8.24 DMP has primary responsibility for responding to instances of well failure. When a well failure occurs, operators must provide DMP with the details of the incident:

As soon as they have something like that [a well failure], the first thing they do is they shut the well in. They have to report to DMP; it is a requirement. They will give us a report actually outlining what occurred and the remedial process they are going to take.

If we feel it is necessary, we will send an inspector out...to actually inspect what is going on and the remedial process that goes on...also

⁴⁰⁰ S Patel, S Webster & K Jonasson, ‘Review of well integrity in Western Australia’, *Petroleum in Western Australia*, April 2015, p 24.

*under environmental regulations they are required to submit any information about spills...*⁴⁰¹

- 8.25 Part 7 of the PGER Regulations compel operators to notify DMP if a ‘significant event’ occurs during the recovery of petroleum. A significant event may include a new or increased risk to the recovery of the resource (which would include a well failure that affects gas flow rate) or an event which may have effects outside the licence area (for example, aquifer depletion caused by petroleum extraction: regulation 62(1)(d), PGER Regulations). Notice must be given orally within two hours of the significant event occurring, or else a \$10 000 fine may apply: regulation 62(3).
- 8.26 Regulation 33 of the PGER Regulations creates an offence if an operator has identified a new ‘well integrity hazard’ or an existing risk at a well has increased and the operator does not control that risk: the penalty is a maximum fine of \$10 000.
- 8.27 A ‘well integrity risk’ is defined in regulation 4 to mean an event that may:
- (a) compromise the integrity of a well; or*
 - (b) involve risk of damage to –*
 - (i) an underground formation that contains petroleum or geothermal energy resources; or*
 - (ii) an aquifer; or*
 - (iii) any other part of the environment.*

Well failure rates in Western Australia

- 8.28 In 2015, DMP conducted a survey on 1035 non-decommissioned wells (both offshore and onshore wells) which found that:

*the vast majority of petroleum and geothermal wells are drilled, completed, produced and decommissioned without any adverse environmental impacts.*⁴⁰²

- 8.29 The results of DMP’s analysis of well integrity failure are illustrated below:

⁴⁰¹ Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, p 14.

⁴⁰² S Patel, S Webster & K Jonasson, ‘Review of well integrity in Western Australia’, *Petroleum in Western Australia*, April 2015, p 24.

Type of failure	Number of wells affected	Percentage (%) of total number of wells in WA
Tubing failure	86	8.3
Casing failure	22	2.1
Wellhead / Christmas tree failure	14	1.3
Total	122	11.7

8.30 DMP made the following key findings:

- 122 petroleum wells of the 1035 non-decommissioned wells surveyed had well integrity issues (11.7 per cent), but none of these had leakage to the external environment (a ‘leak path’).
- Well control failures occur more often in the drilling phase than after drilling (the completion phase) due to unexpected high pressure in the formation or other factors related to drilling.
- During the production phase of a well, the tubing pipe (used to carry the fluids being produced out of, or injected into, the well) fails more often than other types of well failure. This is most likely due to the tubing being in contact with hydrocarbon flow.
- Of the 86 wells with a tubing failure, 61 were on Barrow Island and 57 wells were over 40 years old. Overall, the tubing failure rate in Western Australia is considered to be ‘very low.’
- Christmas tree failures occur far less frequently than other types of failure primarily because the equipment is readily accessible for maintenance and monitoring. The age of equipment is a factor in this type of failure, with many failures occurring in wells over 40 years old.

8.31 DMP’s approach to regulating the unconventional gas industry is to be ‘transparent,’ ‘risk based’ and is based on the UK approach of mitigating risks to a level ‘as low as reasonably practical.’⁴⁰³ The department’s resource legislation (including its penalty regime) has been modelled around the concept that risks are identified with their likelihood, consequences and how they can be mitigated and remediated should there be any errors or mistakes.⁴⁰⁴

8.32 UK regulators use a ‘goal-based approach’ to risk management, which requires operators to ‘identify and assess risks in a way that fosters innovation and continuous

⁴⁰³ Used interchangeably with ‘as low as reasonably practicable’. Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum, *Transcript of Evidence*, 17 February 2014, p 10.

⁴⁰⁴ *Ibid*, p 10.

improvement.’⁴⁰⁵ The term ‘As Low as Reasonably Practicable’ (**ALARP**) is used in the UK as part of a risk or safety assessment in industry or government. DMP’s ‘objective-based’ approach is similar in scope to the UK and requires industry to best determine and provide justification to DMP about how objectives will be achieved.⁴⁰⁶

8.33 The concept of well integrity includes ‘the tubing, the casing, the valves on the surface, the flow lines’ and therefore DMP describes a failure in a well’s Christmas tree as a well integrity failure, rather than a barrier failure. DMP’s statistics state that:

of the 953 active petroleum wells surveyed, 9% have had production tubing failures...and 3% have had production casing failures well away from aquifers which were still protected by the surface and conductor casings.

*There have been no failures of surface or conductor casings.*⁴⁰⁷

8.34 The Committee notes that well failure data for one area also can vary greatly over a relatively short span of time, as illustrated in the data extract below.⁴⁰⁸ The table below outlines well failure rates in the same area of Pennsylvania, but with data taken over varying time periods from different academic studies:

Location	No. wells studied	% wells with barrier or integrity failure	Additional information	Published source
Onshore Marcellus Shale, PA, wells drilled 1958-2013	8030	6.26	Well reports 2005-2013. Well integrity and barrier failure. 1.27% leak to surface.	Davies (2014)
Onshore Marcellus Shale, PA, wells drilled 2010-2012	4602	4.8	Wells drilled 2010-2012. Well barrier and integrity failure.	Ingraffea (2012) ⁴⁰⁹
Onshore Marcellus Shale, PA, wells drilled 2008-2013	6466	3.4	Wells drilled 2005-2012. Well integrity and barrier issues. Leak to surface in 0.24% wells.	Vidic et al (2013) ⁴¹⁰
Onshore Marcellus Shale, PA, wells drilled 2008-2011	3533	2.58	Wells drilled 2008-2011. Well integrity and barrier failure.	Considine et al (2013) ⁴¹¹

⁴⁰⁵ Royal Society and Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 4.

⁴⁰⁶ 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*, June 2015, p 5.

⁴⁰⁷ Department of Mines and Petroleum, *Corrected Hansard and Responses to DMP Questions on Notice: Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas Hearing of 17 February 2014*, 7 March 2014, p 12.

⁴⁰⁸ Table extracted from data compiled and published in: R Davies et al, ‘Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation’, *Marine and Petroleum Geology*, 2014, p 8. The full table is reproduced at **Appendix 12**.

⁴⁰⁹ A Ingraffea, *Fluid Migration Mechanisms Due to Faulty Well Design and/or Construction: An Overview and Recent Experiences in the Pennsylvania Marcellus Play*, PSE Healthy Energy, January 2013.

⁴¹⁰ R Vidic et al ‘Impact of shale gas development on regional water quality’, *Science*, 340, 1235009, 2013.

- 8.35 The same well failure data can therefore be interpreted in different ways to result in varying conclusions. The Committee is of the view that the definition of well failure and well integrity is important, but reiterates that ‘there is absolutely no universal definition for well-failure frequency.’⁴¹²
- 8.36 The data also demonstrates that the age of a well and its construction are significant factors in predicting its potential integrity: failure rates appear to decrease with newer (better) wells. The Committee is of the view that these factors must be primary considerations for operators in the unconventional gas industry:
- it must be remembered that failures of the past are what our knowledge of today is built upon, and as learnings progress, the failure rates of a later time should be lower than those of the era before it...A key issue with operators is how they capture and incorporate learnings into the next design.*⁴¹³
- 8.37 The Committee notes that there is currently a lack of data on the long term durability of unconventional gas wells. However, research and modelling of underground carbon dioxide storage has concluded that using cement as a well seal is a successful strategy to reduce the probability of wells failing. Long term simulations of the chemical reactions that would occur within a carbon dioxide storage well have found that, over 1000 years, the cement seals in such a well would only have moved approximately one metre.⁴¹⁴
- 8.38 Wells in Western Australia must be constructed with a minimum of three strings of casings (see paragraph 5.89), which ensures that the risk of a well’s integrity failing is minimised.

Finding 38: The Committee finds that a well failure does not necessarily result in a leak to the external environment, therefore it is incorrect to equate all well failures with environmental impacts.

⁴¹¹ T Considine et al, ‘Environmental regulation and compliance of Marcellus shale gas drilling’, *Environmental Geoscience*, 20, 2013.

⁴¹² G King & D King, ‘Environmental Risk Arising From Well-Construction Failure-Differences Between Barrier and Well Failure, and Estimates of Failure Frequency Across Common Well Types, Locations and Well Age’, *SPE Production & Operations*, November 2013, p 323.

⁴¹³ Ibid, p 327.

⁴¹⁴ K Yamaguchi et al, ‘The long-term corrosion behaviour of abandoned wells under CO₂ geological storage conditions: (3) Assessment of long-term (1,000 year) performance of abandoned wells for geological storage’, *Energy Procedia*, 37, 2013, p 5815.

Finding 39: The Committee finds that Western Australian best practice in well design and construction means that it is more meaningful to refer to a well failure having an impact on the environment when the well failure results in a leak path to the environment. According to evidence from the Department of Mines and Petroleum, there have been no failures of surface or conductor casings.

Footprint of hydraulic fracturing after operations have ceased

8.39 Any ongoing issues in the reclamation of land previously used for mining will depend upon the individual landscape and intended future use of the land. The Committee acknowledges the community's concerns that contamination may not become apparent until years after a well has been completed and the site abandoned. Soil quality issues and any negative impacts on flora and fauna in the area are also important considerations when rehabilitating land after mining.

8.40 The term 'reclamation' of land is used interchangeably with 'rehabilitation' of land: both refer to the process of returning an area to its former state following degradation or disturbance by human activity. In relation to mine closure, rehabilitation is defined as:

*the return of disturbed land to a safe, stable, non-polluting/non-contaminating landform in an ecologically sustainable manner that is productive and/or self-sustaining, consistent with the agreed post-mining land use.*⁴¹⁵

8.41 Section 91A of the PGERA requires an operator (who is conducting petroleum activities) to ensure that they maintain insurance for expenses and liabilities connected with the petroleum activity, not only for the actual work being undertaken but also:

including expenses of complying with directions [from the Minister] with respect to the clean-up or other remedying of the effects of the escape of petroleum or geothermal energy resources, as the case requires.

8.42 This obligation works together with the requirements in section 90 of the PGERA to carry out work practices in a 'proper and workmanlike manner' and in accordance with 'good oil-field practice.'⁴¹⁶

⁴¹⁵ Department of Mines and Petroleum & Environmental Protection Authority, *Guidelines for Preparing Mine Closure Plans*, May 2015, p 47.

⁴¹⁶ 'Good oil-field practice' is defined in section 5 of the PGERA as being 'all those things that are generally accepted as good and safe in the carrying on of exploration for petroleum, or in the operations for the recovery of petroleum, as the case may be.'

Abandoned, orphaned or lost wells

- 8.43 An ‘abandoned well’ is a well that did not locate hydrocarbons to a level to be extracted economically or a well that has reached the end of its production lifecycle. Abandonment of a well involves cementing and capping the pipe to ensure that the well is not a threat to water systems or likely to lead to gas emissions;⁴¹⁷ this is also referred to as ‘plug and abandon’ or decommissioning. Successful well abandonment depends on appropriate well design and construction, the type of cement used and the procedure used for injecting the well with cement.⁴¹⁸ The Committee notes that it is unfortunate that the term used to refer to wells that have reached the end of their productive lifecycle and which will be subject to ongoing monitoring is ‘abandoned’ as it may have negative implications.
- 8.44 ‘Lost’ or ‘orphan’ wells are different to abandoned or decommissioned wells as the party responsible for the well’s maintenance no longer exists or its records cannot be found. The Committee notes that where the company that drilled the well no longer exists or has been taken over by another entity, it can be extremely difficult to assign responsibility for any well failures that may occur in that well. This has ongoing implications for landowners and regulators, both from an environmental perspective and for the question of legal liability and costs.
- 8.45 In the USA, there are between 828 000 and 1.06 million lost oil and gas wells which were drilled prior to a formal regulatory system being in place and therefore have no information available in state databases.⁴¹⁹
- 8.46 The Committee notes that some regions in the USA struggle to plug wells at the same rate at which wells are being abandoned: for example, New York State plugged 25 per cent of its abandoned wells in 2010, down from 27 per cent in 1994.⁴²⁰ Texas, on the other hand, has an ‘aggressive program’ for plugging abandoned wells: more than 41 000 wells were plugged between 1991 and 2009 as part of its well plugging program, at a cost of US\$80 million to the state.⁴²¹ The Oil & Gas Regulation and Cleanup Fund (**OGRC Fund**) has been administered by the Railroad Commission of Texas since 2011.
- 8.47 In Texas, the Railroad Commission administers its State Managed Cleanup Program, using the OGRC Fund, where fees are collected from operators as part of permit

⁴¹⁷ ACOLA Report, p 176.

⁴¹⁸ New South Wales, Chief Scientist & Engineer, *Independent Review of Coal Seam Gas Activities in NSW Information Paper: Abandoned wells*, September 2014, p iii.

⁴¹⁹ RJ Davies et al, ‘Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation’, *Marine and Petroleum Geology*, 2014, p 9.

⁴²⁰ *Ibid*, p 9.

⁴²¹ *Ibid*, p 9.

applications, statutory fees and bond fees.⁴²² A site becomes a candidate for state cleanup if the responsible party cannot, or refuses to, take action or the well site is orphaned. The Railroad Commission will then prioritise the sites for cleanup, depending on the severity of the site's risk to the environment or public health. The Railroad Commission of Texas publishes quarterly reports on the expenditure and details of the sites that it has remediated and makes these reports available to the public.⁴²³

- 8.48 In contrast, in Western Australia, the process of preparing a well for abandonment begins when an operator lodges the EP for the petroleum activity with DMP (see paragraph 4.14).
- 8.49 Further to the EP information, the Well Management Plan (**WMP**) and Field Management Plan (**FMP**) submitted prior to the commencement of any activity must include details relating to abandonment and decommissioning of wells, how the operator plans to close a field, and rehabilitation of the land (Schedules 1 and 3, PGER Regulations).
- 8.50 Where a WMP does not adequately address the risks associated with an activity (including risks related to well abandonment), DMP will not approve the plan. Further, if DMP requests any additional information to assess a WMP, the assessment process is paused until that information is received (thereby delaying activities and acting as an incentive for operators to provide as much information to DMP as possible).⁴²⁴

Finding 40: The Committee finds that, whilst there are some international jurisdictions where lost or orphan wells continue to have an impact on the environment, in contrast, Western Australia has a robust system in place for the monitoring of abandoned wells that begins prior to any petroleum activity taking place.

Long term management of abandoned wells

- 8.51 Most hydrocarbon-producing states in the USA have established funds or programs to manage orphan or legacy wells and to ensure that the land previously used for mining can be adequately rehabilitated. There are various approaches taken to this ongoing monitoring of long term abandoned wells, for example:

⁴²² State of Texas, Railroad Commission, *State Managed Cleanup Program*. Available at: <http://www.rrc.state.tx.us/oil-gas/environmental-cleanup-programs/site-remediation/state-managed-cleanup-program/>. Viewed 15 July 2015.

⁴²³ Reports on site remediation are available at: <http://www.rrc.state.tx.us/oil-gas/environmental-cleanup-programs/oil-gas-regulation-and-cleanup-fund/>.

⁴²⁴ 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.

- California runs an ‘Adopt a Well’ program: the state maintains a list of orphaned wells and interested operators can enter into agreements with the state and the landowner to ‘adopt’ a well and become its permanent operator. Any future liability or any resources that may flow from the adopted well are the responsibility of the new operator.⁴²⁵ At the time of tabling this report, there were over 100 wells available for adoption across California.
- Pennsylvania has a ‘Well Plugging Program’ for orphaned wells, which gives the Department of Environmental Protection the authority to plug and abandon wells where no responsible party can be identified. Under Pennsylvania’s Oil and Gas Act 2012, the state imposes a surcharge of US\$200 on every application for a gas well permit, which is used to fund the Well Plugging Program.⁴²⁶
- In Texas, the Railroad Commission uses its OGRC Fund (see paragraph 8.47) to pay for the plugging of orphaned wells and site remediation programs across the state. The Railroad Commission produces detailed monthly expenditure reports which track the numbers of orphaned wells that are plugged.⁴²⁷ The plugging program is funded through several fees collected from operators, including the initial drilling permit application fee (which ranges from US\$100-US\$200) and the statutory charge collected on each barrel of oil or per thousand cubic feet of gas that is produced in Texas.⁴²⁸

8.52 The Committee notes that there no similar programs currently operational in Western Australia for abandoned wells.

Mining Rehabilitation Fund for abandoned mines

8.53 In Western Australia, DMP administers the Mining Rehabilitation Fund (**MRF**) using the framework established in the *Mining Rehabilitation Fund Act 2012* and the Mining Rehabilitation Fund Regulations 2013. The MRF applies to holders of tenements issued under the *Mining Act 1978* (that is, minerals) who must contribute an annual

⁴²⁵ State of California, Department of Conservation, *Oil, Gas and Geothermal Idle and Orphan Well Program*. Available at: http://www.consrv.ca.gov/dog/idle_well/Pages/idle_well.aspx. Viewed 15 July 2015.

⁴²⁶ State of Pennsylvania, Department of Environmental Protection, *The Well Plugging Program*. Available at: <http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/AbandonedOrphanWells/WellPluggingProgram.pdf>. Viewed 15 July 2015.

⁴²⁷ These monthly reports are publicly available from the Railroad Commission of Texas website at: <http://www.rrc.state.tx.us/oil-gas/environmental-cleanup-programs/oil-gas-regulation-and-cleanup-fund/ogrc-plugging-monthly-reports/> and contain a running total of the costs involved in administering the cleanup fund.

⁴²⁸ State of Texas, Railroad Commission, *Well Plugging Primer*, January 2000. Available at: <http://www.rrc.state.tx.us/media/6358/plugprimer1.pdf>. Viewed 15 July 2015.

levy to the MRF.⁴²⁹ The funds and interest earned are used to rehabilitate abandoned mines across Western Australia.

- 8.54 The MRF was intended to replace unconditional performance bonds, which were first implemented in the 1980s. The previous system did not generate sufficient funds to keep pace with the actual costs of rehabilitating land: in 2010, bonds reflected only 25 per cent of the cost of land rehabilitation.⁴³⁰ DMP notes that:

*This [the MRF] is a new approach to reducing the State's exposure to the liability of poor rehabilitation of mine sites. It should, over time, provide greater protection to the State than the previous system of bonds. It will also provide funds to progressively rehabilitate the large number of abandoned mines across the State...Parliament can be much more assured now than three years ago that the State has a reliable view of compliance with conditions, will be better protected from liabilities, and is securing the returns that it seeks from mining.*⁴³¹

- 8.55 There are over 11 000 abandoned mine sites in Western Australia and DMP submitted that the funds available from the MRF to rehabilitate these sites will reach 'somewhere between \$500 million and \$700 million' in the next seven to ten years.⁴³²

- 8.56 Currently there is more than \$33 million in the MRF, which DMP projects will increase by around \$26 million per year, not including interest earned on the amount.⁴³³ The existence of the MRF 'encourages early and ongoing environmental rehabilitation of mine sites operating under the Mining Act as this reduces the levy payments.'⁴³⁴

- 8.57 Recent statistics also reveal that:

- 1130 square kilometres of land in Western Australia is currently disturbed by mining activities

⁴²⁹ Schedule 1 of the Mining Rehabilitation Fund Regulations 2013 refers to a 'rehabilitation liability estimate' being an estimate of the amount owed as a levy by calculating the amount and type of infrastructure on and size of, a mine: the more built-up the site, the more the tenement holder will be required to contribute: see Item 1, Schedule 1 of the Mining Rehabilitation Fund Regulations 2013.

⁴³⁰ Department of Mines and Petroleum, *Policy options for mining securities in Western Australia: preliminary discussion paper*, November 2010, p 1.

⁴³¹ Department of Mines and Petroleum, *The Mining Rehabilitation Fund – The First Two Years*, April 2015, p 8.

⁴³² Mr Richard Sellers, Director General, Department of Mines and Petroleum, *Transcript of Evidence*, 21 August 2013, p 13.

⁴³³ Department of Mines and Petroleum, *The Mining Rehabilitation Fund – The First Two Years*, April 2015, p 9.

⁴³⁴ *Ibid*, p 8.

- 318 square kilometres of land is under rehabilitation.⁴³⁵

8.58 The Minister for Mines and Petroleum advised the Committee that since the OAG 2011 Report ‘significant work’ has been undertaken to address the issue of mine abandonment in Western Australia. This includes:

1) The introduction in minimum standards for mine site closure (in 2011 DMP and the Environmental Protection Authority (EPA) jointly released the first Mine Closure Plan standards which have now become compulsory across Mining Act sites in Western Australia).

2) The reform of securities relating to mine site rehabilitation has been addressed by the Mining Rehabilitation Fund Act 2012. A perpetual fund to protect the State and the community from having to bear the costs associated with mine site abandonment now exists.

3) The development of policies and processes relating to the management and rehabilitation of abandoned mine sites (DMP has recently commenced consultation with stakeholders on these policies).⁴³⁶

8.59 In contrast, for petroleum activities DMP requires operators to fund their clean-up operations using the insurance condition on a permit (see paragraph 8.41), but this statutory requirement only applies as directed by the Minister ‘from time to time.’

8.60 The Committee notes that there is currently no equivalent rehabilitation fund for petroleum activities in Western Australia.

Finding 41: The Committee finds that the Mining Rehabilitation Fund that applies to tenements issued under the *Mining Act 1978* is a positive development in the ongoing rehabilitation of land used for mining activities.

Recommendation 11: The Committee recommends that a fund similar to the Mining Rehabilitation Fund under the *Mining Rehabilitation Fund Act 2012* be established for activities governed by the *Petroleum and Geothermal Energy Act 1967*.

⁴³⁵ Department of Mines and Petroleum, *The Mining Rehabilitation Fund – The First Two Years*, April 2015, p 8. Western Australia’s total land area (including islands) is approximately 2.53 million square kilometres.

⁴³⁶ Letter from Hon Bill Marmion MLA, Minister for Mines and Petroleum, 10 April 2015, p 4.

CHAPTER 9

INDUCED SEISMICITY, AIR QUALITY AND HUMAN HEALTH IMPACTS

While fracking refers to one stage in the process of shale development...the fracking process never occurs by itself. When fracking comes to a community, it brings with it the full range of the oil and natural gas development process – from well construction to extraction.

Center for Environmental Health (USA)

*Toxic & Dirty Secrets: The truth about fracking & your family's health*⁴³⁷

- 9.1 Many submissions to this inquiry referred to potential impacts of hydraulic fracturing for unconventional gas on human health and on the atmosphere. Whilst the Committee has endeavoured to address these concerns individually, many of these concerns can be related to broader concerns with the safety of groundwater supplies and the chemicals used in hydraulic fracturing, which have been dealt with previously in this report.
- 9.2 The following are examples of submissions from the community that reveal these concerns:

*Exposure to air pollution resulting from fracking has been documented to increase the risk of cancers (particularly leukaemia), neurological diseases, impacts to the nervous system, asthma, along with [a] plethora of other undesirable health effects.*⁴³⁸

*The impacts on people's physical and mental health should be considered.*⁴³⁹

*[As] a member of the community, I do have some concerns about health risks associated with fracking. Water contamination, air pollution, the threat of harmful chemicals will all impact the quality of life of local residents.*⁴⁴⁰

Western Australia's geology is billions of years old and during that time, trillions of faults of all sizes and shapes have formed from the Earth's violent past. The unconventional gas industry wants to drill thousands and even hundreds of thousands of wells through this old, dry, cracked

⁴³⁷ Center for Environmental Health, *Toxic & Dirty Secrets: The truth about fracking & your family's health*, November 2010, p 6.

⁴³⁸ Submission from Angus King, 19 September 2013, p 1.

⁴³⁹ Submission from Cliff Harris, 24 September 2013, p 2.

⁴⁴⁰ Submission from Ronda Harman, 20 September 2013, p 1.

*land we call home. There is no doubt that gas and corrosive liquid will make its way up through the multiple layers of rock over the years.*⁴⁴¹

INDUCED SEISMICITY

- 9.3 The Committee notes that there has been a great deal of media attention overseas on the phenomenon of earthquakes being caused by hydraulic fracturing. Seismicity induced by anthropogenic factors is not only a concern for the unconventional gas industry: human activities have long caused earthquake events, such as the building of dams or coal mining in the UK.
- 9.4 The increased media attention on induced seismicity in the UK and the USA caused by hydraulic fracturing has resulted in a significant amount of scientific data available on the topic. Whilst there have been several well-documented and researched incidents of seismic events associated with hydraulic fracturing in the UK and USA, there have been no reported incidents of similar events in Australia, related to either CSG or shale gas.⁴⁴² This chapter will therefore necessarily focus on the research and experience of the UK and USA.

When induced earthquakes occur

- 9.5 Induced seismicity specifically associated with shale gas extraction falls into two categories: either seismicity induced by the hydraulic fracturing process itself, or the disposal of waste fluids by re-injection deep into the earth (once the fracturing itself has finished).⁴⁴³ Microseismic events are a normal feature of hydraulic fracturing, as the intent of the process is in fact to cause fractures in rock to release the hydrocarbons within. The intensity of these seismic events, however, is likely to be very small due to the great depth at which shale gas is extracted (compared to the shallow depths of coal mining for example).⁴⁴⁴
- 9.6 Researchers have found that hydraulic fracturing can trigger seismicity because it can cause an increase in the fluid pressure in a fault zone in the earth; indeed, ‘sometimes, induced seismicity can reveal the presence of previously unknown faults.’⁴⁴⁵ In the context of human activities, however, hydraulic fracturing is a ‘relatively benign mechanism compared to other anthropogenic triggers, probably because of the low

⁴⁴¹ Submission 84 from Dean Leggo, 20 September 2013, p 1.

⁴⁴² ACOLA Report, p 133.

⁴⁴³ Ibid, p 133.

⁴⁴⁴ Royal Society and Royal Academy of Engineering, *Shale Gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 41.

⁴⁴⁵ R Davies, G Foulger, A Bindley & P Styles, ‘Induced Seismicity and Hydraulic Fracturing for the Recovery of Hydrocarbons’, *Marine and Petroleum Geology*, vol. 46, August 2013, p 8.

volumes of fluid and short pumping times used.’⁴⁴⁶ According to the BGS, the risk of seismic events induced by the process itself is ‘exaggerated.’⁴⁴⁷

- 9.7 In the UK, there are many areas with potential shale gas resources that occur close to fault lines. **Figure 29** illustrates that these fault lines often intersect the UK’s shale gas resources, which may increase the likelihood of seismic events related to hydraulic fracturing.

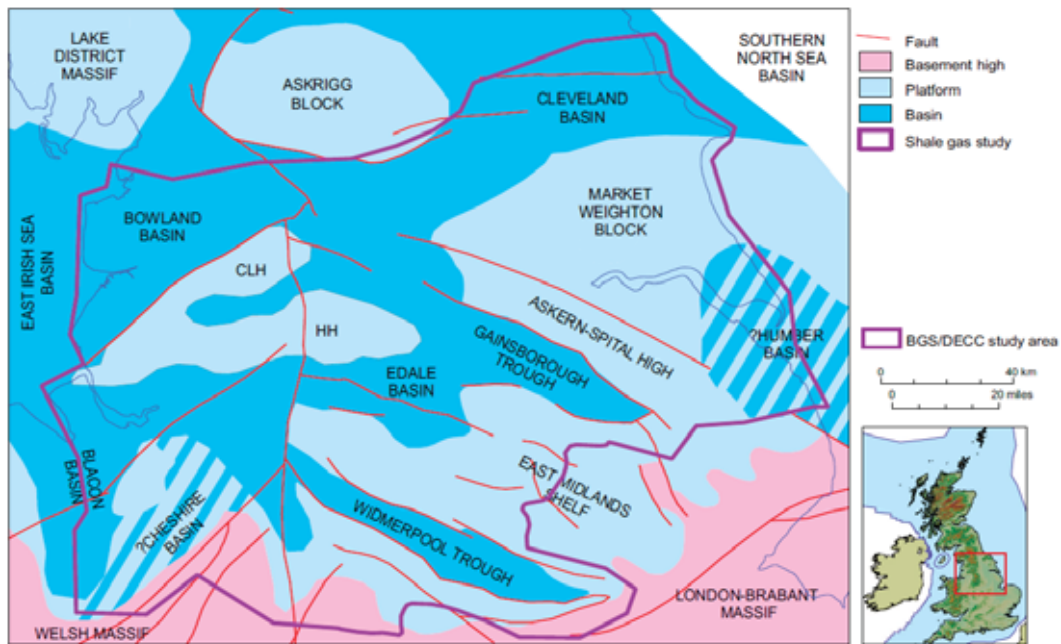


Figure 29. Early Carboniferous basins and platforms of central Britain, showing fault lines and shale gas basins [Source: British Geological Survey, Bowland Shale Gas Study, June 2013]

- 9.8 A notable example of a hydraulic fracturing operation directly causing an induced seismic event occurred in Lancashire, UK in 2011. Shortly after the Preese Hall-1 well owned by Cuadrilla Resources was hydraulically fractured on 1 April 2011 and 27 May 2011, two earthquakes with magnitudes measuring 2.3M_L and 1.5 M_L⁴⁴⁸ were detected in the Blackpool area. In total, there were six fracture treatments carried out on the well, with the largest magnitude event being 2.3M_L, which occurred 10 hours after the well was shut-in under high pressure.
- 9.9 To illustrate the relative impact of an earthquake’s magnitude, a seismic event with magnitude between 3.0-3.9M_L on the Richter scale would be similar in effect to the

⁴⁴⁶ R Davies, G Foulger, A Bindley & P Styles, ‘Induced Seismicity and Hydraulic Fracturing for the Recovery of Hydrocarbons’, *Marine and Petroleum Geology*, vol. 46, August 2013, p 2.

⁴⁴⁷ G Lawton, ‘Fracking risk is exaggerated’, *New Scientist*, 11 January 2012, quoted in: United Kingdom, House of Commons Library Note, *Shale Gas and Fracking*, 25 June 2015, p 27.

⁴⁴⁸ Local magnitude, also known as the Richter scale for earthquakes. ‘Magnitude’ is a measure of the energy released in an earthquake, while ‘intensity’ is an expression of the perceived effects at the surface (‘ground shaking effect’).

vibrations felt from a large truck passing on the street. In contrast, the 2011 Tohoku earthquake that occurred off the northeast coast of Japan measured 9.0M_L in magnitude: this is classified as a ‘great earthquake’ on the Richter scale and can result in the total destruction of an area.

- 9.10 Cuadrilla Resources ceased its operations on the well and commissioned a number of studies to investigate the link between earthquakes and Cuadrilla’s drilling. A group of independent experts in induced seismicity and shale gas geology also provided advice and recommendations on action to mitigate the risk of induced seismic events occurring in the future.⁴⁴⁹ The report found that the seismic events at Blackpool were caused by the hydraulic fracture treatments at the Preese Hall-1 well and were related to an existing fault in the area being subjected to high pressure and fluid injection.⁴⁵⁰
- 9.11 The incident at Preese Hall resulted in the UK implementing a ‘traffic light’ system to identify unusual seismic activity requiring different levels of response (see paragraph 9.18).
- 9.12 Since the incident at Blackpool, more research has been undertaken to investigate the other potential risk of induced seismicity from hydraulic fracturing: re-injection of wastewater. Studies from the USA, for example, concluded that the most likely cause of increased seismicity in the Dallas-Fort Worth area of Texas was probably a result of injecting waste flowback water derived from hydraulic fracturing for shale gas.⁴⁵¹
- 9.13 The United States Geological Survey links the re-injection of wastewater to induced seismicity, more so than the hydraulic fracturing itself:

*Wastewater injection increases the underground pore pressure, which may lubricate nearby faults thereby making earthquakes more likely to occur. Although the disposal process has the potential to trigger earthquakes, most wastewater disposal wells do not produce felt earthquakes.*⁴⁵²

- 9.14 Hydraulic fracturing itself will usually generate only very small magnitude earthquakes, compared to processes such as wastewater injection.⁴⁵³ Disposal of fluids involves a

⁴⁴⁹ C Green, P Styles & B Baptie, *Preese Hall Shale Gas and Fracturing: Review and Recommendations for Induced Seismic Mitigation*, April 2012.

⁴⁵⁰ Ibid, p 12.

⁴⁵¹ C Frohlich, C Hayward & B Stump, ‘The Dallas-Fort Worth Earthquake Sequence: October 2008 through May 2009’, *Bulletin of the Seismological Society of America*, February 2011, pp 32-340.

⁴⁵² United States Geological Society, News Release, *New Insight on Ground Shaking from Man-Made Earthquakes*, 23 April 2015. Available at: http://www.usgs.gov/newsroom/article_pf.asp?ID=4202. Viewed 28 April 2015.

⁴⁵³ R Davies, G Foulger, A Bindley & P Styles, ‘Induced Seismicity and Hydraulic Fracturing for the Recovery of Hydrocarbons’, *Marine and Petroleum Geology*, vol. 46, August 2013, p 18.

longer length of time over which larger volumes of fluid can allow greater pressures to build up underground, potentially resulting in induced seismic events.⁴⁵⁴

- 9.15 Re-injection of wastewater could occur in Western Australia if practical and if a suitable ‘injection zone’ were available nearby.⁴⁵⁵ According to DMP, ‘reinjection of produced water into aquifers is not permitted to avoid any degradation of the quality of groundwater in aquifers’ (see paragraph 7.27).
- 9.16 The overall consensus from experts is that the seismicity associated with deep hydraulic fracturing of shales does not present a significant problem.⁴⁵⁶ The Committee notes however that, whilst the likelihood may be low, the risk and public perception of the risk combine to make mitigation and prevention of induced seismicity a sensible course of action for industry.

Finding 42: The Committee finds that the risk of induced seismicity associated with hydraulic fracturing of shale plays at depth is negligible.

Finding 43: The Committee finds that the Department of Mines and Petroleum’s policy of not permitting reinjection of wastewater into aquifers has merit and is supported.

Finding 44: The Committee finds that reinjection should not generally be the preferred option for the disposal of wastewater during hydraulic fracturing operations.

How to minimise the risk of induced earthquakes

- 9.17 Research has found that the risk of induced seismicity can be mitigated by appropriate baseline monitoring of an area’s geology in order to establish background seismicity potential and to identify any possibly active faults in the region.⁴⁵⁷
- 9.18 UK regulators responded to the seismic events at Preese Hall by implementing a ‘traffic light’ system to mitigate induced seismicity:
- **Green:** injection proceeds as planned.

⁴⁵⁴ Royal Society and Royal Academy of Engineering, *Shale Gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 46.

⁴⁵⁵ Submission 105 from Department of Mines and Petroleum, 3 October 2013, p 15.

⁴⁵⁶ ACOLA Report, p 133.

⁴⁵⁷ C Green, P Styles & B Baptie, *Preese Hall Shale Gas and Fracturing: Review and Recommendations for Induced Seismic Mitigation*, April 2012, p 14.

- **Amber:** injection proceeds with caution, possibly at reduced rates. Monitoring is intensified.
 - **Red:** Injection is suspended immediately.⁴⁵⁸
- 9.19 The Royal Society and Royal Academy of Engineering also referred to strategies which would mitigate the risk of induced seismicity that may result from the re-injection of wastewater:
- Avoid injection into active faults and faults in brittle rock.
 - Minimise pressure changes at depth.
 - Establish modification protocols in advance.
 - Be prepared to alter plans.⁴⁵⁹
- 9.20 The Committee notes that a common theme amongst these mitigation strategies is knowledge of the area's geology and presence of any faults. This further underlines the importance of baseline data and seismic surveys to any hydraulic fracturing operations which may be planned in a region.

Likelihood of earthquakes occurring in Western Australia

- 9.21 Australia is generally considered a 'stable intraplate continental region' that nonetheless occasionally experiences damaging earthquakes as a result of our geology.⁴⁶⁰ Western Australia tends to experience less earthquakes than other regions in the country.
- 9.22 **Figure 30** illustrates that Western Australia has low background seismicity (compared to other areas in Australia). The Committee is of the view that induced earthquakes in Western Australia are therefore quite remote possibilities.

⁴⁵⁸ United Kingdom, Department of Energy and Climate Change, *Traffic light monitoring system*, 2013.

⁴⁵⁹ Royal Society and Royal Academy of Engineering, *Shale Gas extraction in the UK: a review of hydraulic fracturing*, June 2012, p 46.

⁴⁶⁰ R Blewett (ed.), *Shaping a Nation: A Geology of Australia*, Geoscience Australia/ANU E-Press, Canberra, 2012, p 52.

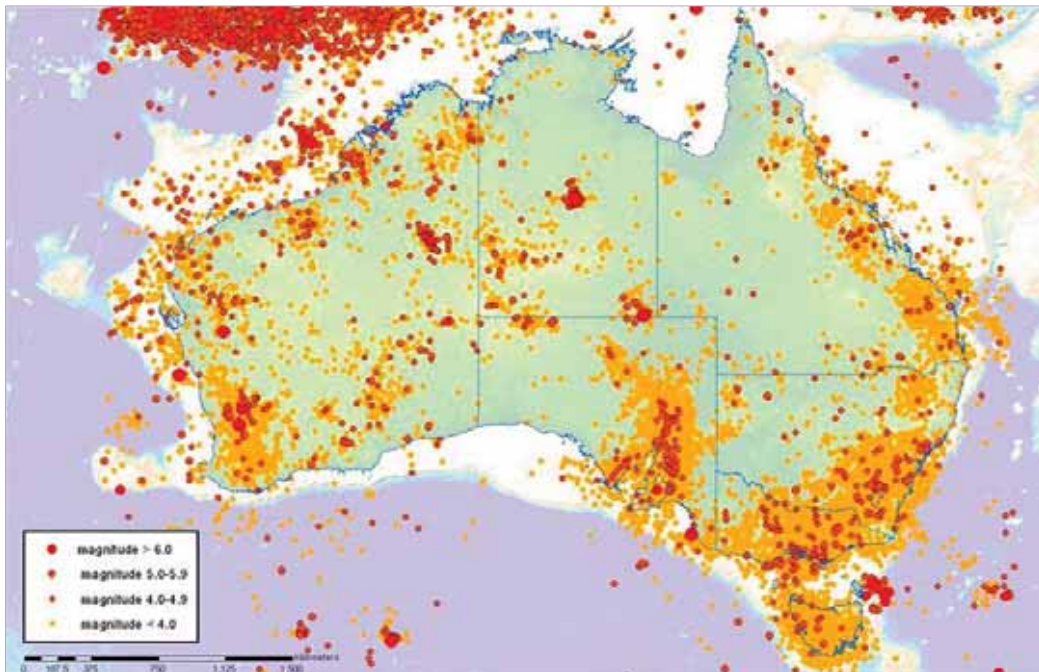


Figure 30. All Australian earthquakes located up to 2011 [Source: Geoscience Australia]

9.23 According to ACOLA, the risk of induced seismicity in the Australian context can be managed by adopting a range of mitigation steps, including:

better knowledge of fault structures close to disposal sites...

adoption of a traffic light monitoring system that uses real-time seismic monitoring...

transparent communication and documentation, both to the public and regulatory authorities...[and]

*there may be a need to enhance the Australian national seismic network operated by Geoscience Australia in prioritised locations.*⁴⁶¹

9.24 The Committee notes that any risk of induced seismic events can be managed by using the best available seismic information and processes (such as 3D seismic surveys where possible) and real-time data.

Finding 45: The Committee finds that, given Western Australia’s geology and low background seismicity, the State is unlikely to experience any negative effects from induced seismicity as a result of hydraulic fracturing.

⁴⁶¹ ACOLA Report, p 137.

Finding 46: The Committee finds that the risk of induced seismicity linked to hydraulic fracturing can be effectively reduced by implementing mitigation strategies and using baseline data to monitor seismicity before, during and after any hydraulic fracturing activities.

Finding 47: The Committee finds that a traffic light monitoring system for induced seismic events related to hydraulic fracturing has merit, but is unlikely to be necessary in Western Australia.

AIR QUALITY

9.25 Several submissions to this inquiry referred to the potential for air pollution from the production of unconventional gas.⁴⁶² Concerns raised included the risk of volatile chemicals being released during the production of unconventional gas, as well as the effects of methane flaring and greenhouse gases entering the atmosphere.

9.26 As discussed at paragraph 3.29, one of the Golden Rules developed by the IEA states that operators should:

Eliminate venting, minimise flaring and other emissions

- Target zero venting and minimal flaring of natural gas during well completion and seek to reduce fugitive and vented greenhouse gas emissions during the entire productive life of a well.

- Minimise air pollution from vehicles, drilling rig engines, pump engines and compressors.⁴⁶³

9.27 The Committee notes the following findings made by ACOLA regarding the potential impacts on air quality of hydraulic fracturing for unconventional gas:

Emissions, particularly during the flowback stage, can be ameliorated by the implementation of best practice strategies such as the use of so-called 'green completions', including the adoption of emission capture and/or flaring rather than venting...

At the present time there is a lack of reliable data on the release of methane and related hydrocarbons to the atmosphere along with other gaseous constituents. There will be a need to implement baseline and

⁴⁶² For example: Submission 7 from The Wilderness Society (WA) Inc., 5 September and Submission 50 from Alliance for a Clean Environment Inc., 19 September 2013.

⁴⁶³ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012, p 46.

*ongoing atmospheric monitoring of shale gas because of the nature of the production process, together with a code of practice for the management of GHG emissions.*⁴⁶⁴

9.28 The Committee also notes that greenhouse gas emissions must be reported to the Commonwealth Clean Energy Regulator pursuant to the *National Greenhouse and Energy Reporting Act 2007* (Cth).

9.29 Whilst this inquiry has focused on shale gas, it is pertinent to note a recent CSIRO report on potential air contamination from methane emissions from CSG wells. The CSIRO found that of 43 CSG well sites in Queensland and NSW tested:

Emission rates from production sites ranged from zero to a maximum of about 44 g min⁻¹. The highest emission rate was due to CH₄ released from a vent on the well pad while the lowest emitters were two plugged and abandoned wells and a suspended well.

All of the producing wells were found to have some level of emissions, although in all cases these were very low compared to overall production. Emissions were found to comprise equipment leaks, venting, pneumatic device operation and engine exhaust. The wells examined in this study did not show any evidence of CH₄ migration outside the well casing...

*the small sample examined during this study may not be truly representative of the total well population. It is also apparent that emissions may vary over time, for instance due to repair and maintenance activities...and the uncertainty surrounding some of these estimates remains high.*⁴⁶⁵

9.30 The CSIRO report also found ‘no observable correlation between production and leak rate’ and that the ‘highest emissions were from wells that were not producing gas at the time of the measurements.’⁴⁶⁶ The Committee notes the ongoing issue of the legacy of abandoned gas wells and how these may impact upon the rehabilitation of land that has been subject to hydraulic fracturing (see CHAPTER 8).

⁴⁶⁴ ACOLA Report, pp 26-7.

⁴⁶⁵ S Day, M Dell’Amico, R Fry, H Javanmard Tousi, *Field Measurements of Fugitive Emissions from Equipment and Well Casings in Australian Coal Seam Gas Production Facilities: Report to the Department of the Environment*, CSIRO, June 2014, p 36.

⁴⁶⁶ *Ibid*, p 34.

EFFECTS ON HUMAN HEALTH

- 9.31 The concerns raised in the submissions about the possible effects of hydraulic fracturing on human health can mostly be traced back to the issue of the use of chemicals, which is discussed in detail at CHAPTER 6.
- 9.32 The Committee notes that there is clearly concern amongst the public in Western Australia regarding the use of open water storage ponds and the appropriate disposal of flowback so as to minimise any potential impact on human health.⁴⁶⁷
- 9.33 Some submitters were concerned about the possible effects of hydraulic fracturing on human health, such as from carcinogenic chemicals being used in the process:

Atmospheric pollution from fracking activities have been shown to increase the risk of:

- *Cancers, in particular leukemia*
- *Neurological diseases*
- *Impacts to the nervous system*
- *Aggravation of existing heart diseases*
- *Asthma and other lung diseases (such as chronic obstructive pulmonary disease)*
- *Headache*
- *Irritation of the throat and eyes.*⁴⁶⁸

- 9.34 The Committee observes that some submitters who expressed concern at the possible effects of hydraulic fracturing on human health often referred to unconfirmed evidence due to the lack of established data on the topic.⁴⁶⁹ ACOLA has also acknowledged the difficulty in assessing human health impacts as:

*there have been many claims made and concerns raised regarding the potential impact of shale gas operations on human health, but there is limited overseas data and very little data in Australia.*⁴⁷⁰

- 9.35 The Committee is of the view that this lack of confirmed data on human health impacts is a knowledge gap which has contributed to community concerns. The recent DoH HHRA provides a valuable source of information to fill this gap.

⁴⁶⁷ Submission 49 from Dr Gregory Glazov, 19 September 2013, p 3.

⁴⁶⁸ Submission 68 from Judith Blyth, 20 September 2013, p 15.

⁴⁶⁹ Including: Submission 50 from Alliance for a Clean Environment Inc., 19 September 2013, Addendum to Submission, p 1 and Submission 73 from Lisa Smith, 20 September 2013, p 4, Submission 99 from Ron Morris, 20 September 2013 and Submission 103, Ruth Mouchemore, 25 September 2013.

⁴⁷⁰ ACOLA Report, p 181.

9.36 According to DoH, the most significant potential risk to public health from hydraulic fracturing is through the contamination of water supplies.⁴⁷¹ The department’s HHRA also referred to the potential adverse health effects of substances used during hydraulic fracturing, if contamination were to occur. The HHRA contains a list of 195 ‘substances of concern’, grouped into four categories (see paragraph 4.116) with an emphasis on the possible carcinogenic effects of substances.

9.37 In the HHRA, the most significant risk that hydraulic fracturing presents to human health was through oral exposure to chemicals through drinking water supplies.⁴⁷² The DoH also refers to the fact that, of the 195 chemicals of concern listed in the HHRA, 40 per cent (78 substances) do not have a guideline or relevant approval by a regulatory agency, 13 are known carcinogens but only five are carcinogenic via oral exposure.

9.38 Table 9 is reproduced from the HHRA:

Sources - Potential Contaminated / Impacted Media	Human Receptors	Exposure Route	Possible Consequences of Contamination Event	Comments
Soil	<ul style="list-style-type: none"> Workers <i>(Not in the scope of this report.)</i>	<ul style="list-style-type: none"> Inhalation of soil vapours Skin contact (dermal) 	<ul style="list-style-type: none"> Aesthetic discomfort from odours Respiratory irritants Skin irritants 	Contaminated soils may act as a source for ongoing groundwater contamination if the spill is not satisfactorily remediated, or degraded in situ.
Local surface water – onsite dams	<ul style="list-style-type: none"> Workers <i>(Not in the scope of this report.)</i>	<ul style="list-style-type: none"> Skin contact (dermal) 	<ul style="list-style-type: none"> Aesthetic discomfort from taste and odour Respiratory irritation Skin irritation 	Workers handling dam water are most likely to be exposed. Potential for off-site contamination during severe rainfall events.
Local surface water – streams/rivers/creeks	<ul style="list-style-type: none"> Workers at downstream industries may be exposed. <i>(Not in the scope of this report.)</i> <ul style="list-style-type: none"> Public – swimming users Private – drinking water 	<ul style="list-style-type: none"> Skin contact (dermal) Inhalation of mists Ingestion 	<ul style="list-style-type: none"> Aesthetic discomfort from odours Respiratory irritation Skin irritation Gastrointestinal irritation Reproductive effects Liver or kidney effects Neurological effects Cancer 	Downstream uses may include industrial or agricultural businesses or small communities requiring residential water supplies. Extent of health impacts is dependent on dose and duration of exposure and susceptibility of exposed individuals.
Local groundwater Including: <ul style="list-style-type: none"> Remote Aboriginal community drinking wells Private residential wells and PDWSAs 	<ul style="list-style-type: none"> Workers at downstream industries. <i>(Not in the scope of this report.)</i> <ul style="list-style-type: none"> Public – swimming users Private – drinking users 	<ul style="list-style-type: none"> Ingestion Skin contact (dermal) Inhalation of mists 	<ul style="list-style-type: none"> Aesthetic discomfort from odours Respiratory irritation Skin irritation Gastrointestinal irritation Reproductive effects Liver or kidney effects Neurological effects Cancer 	Downstream uses may include industrial or agricultural businesses or small communities requiring residential water supplies. Extent of health impacts is dependent on dose and duration of exposure and susceptibility of exposed individuals.

⁴⁷¹ Submission 107 from Department of Health, 4 October 2013, p 4.

⁴⁷² Department of Health, *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supplies: Human Health Risk Assessment*, June 2015, p 26.

9.39 The data describes:

*worst-case hypothesised outcomes assuming the drinking water supply is significantly contaminated and the exposed population receives sufficient dose to exert the described responses.*⁴⁷³

9.40 Despite the consequences in Table 9 being possible and having actually been reported (but not in relation to hydraulic fracturing), the HHRA stipulates that ‘for example, cancer would only be a possible outcome if an individual was to consume drinking water containing a carcinogen over a lifetime’ and ‘risks reduce as distances increase from the operations.’⁴⁷⁴

9.41 The HHRA acknowledges that the lack of data to confirm the origin of chemicals detected in contaminated water near hydraulic fracturing operations is ‘a common finding and limitation of all of the public health reviews’ analysed as part of the HHRA.⁴⁷⁵

9.42 The Committee is of the view that human health effects may also be related to factors which are systematic of broader issues related to the petroleum industry. Mental stress, disruptions to a community as a result of mining development in an area, concern about possible health effects and increased cost of living have all been identified as triggers for potential effects on human health.⁴⁷⁶

9.43 Doctors for the Environment Australia submitted that:

*Solastalgia, the phenomenon of psychological distress arising from loss of familiar and cherished landscape and sense of place, has also been described in the context of extractive industries such as unconventional gas. While this may be dismissed as just a psychological impact, the effects are real and the health impacts include physical as well as psychological symptoms.*⁴⁷⁷

9.44 The Committee notes that some residents in the Midwest of the State may be experiencing the effects of solastalgia. Anecdotal reports of headache clusters, blood noses, migraines, rashes and other health issues attributed to hydraulic fracturing have been raised despite no hydraulic fracturing operations occurring in the locality.

⁴⁷³ Department of Health, *Hydraulic fracturing for shale and tight gas in Western Australian drinking water supplies: Human Health Risk Assessment*, June 2015, p 31.

⁴⁷⁴ Ibid, p 31.

⁴⁷⁵ Ibid, p 30.

⁴⁷⁶ P Vaneckova & H Bambrick, *Approaches to baseline studies of human health in relation to industries with potential environmental impact: Contribution to the independent review of coal seam gas activities in NSW*, Centre for Health Research, University of Western Sydney, August 2014, p 5.

⁴⁷⁷ Submission 87 from Doctors for the Environment Australia Inc., 20 September 2013, p 4.

CHAPTER 10

SOCIAL LICENCE TO OPERATE

Sometimes complaints by local residents about environmental matters are dismissed as 'nimbyism' – 'not in my backyard.' But companies cannot always be trusted to 'do the right thing' and complaints should be taken seriously.

New Zealand Parliamentary Commissioner for the Environment,
*Drilling for oil and gas in New Zealand: Environmental oversight and regulation*⁴⁷⁸

- 10.1 It is apparent from the submissions received that there is a strong opposition to hydraulic fracturing being used as part of unconventional gas development in Western Australia. The Committee has found that a significant proportion of opponents of hydraulic fracturing is also opposed to the development of the mining industry in general, and fossil fuels in particular. The Committee has taken the opportunity to draw attention to the social implications that hydraulic fracturing for unconventional gas may have for Western Australians.
- 10.2 The idea that industry cannot exist in isolation and that members of the public should be included in strategic decisions is a new and emerging area of discussion, particularly for mining and extractive industries. The notion of a social licence to operate blurs the line between industry and community and foreshadows an understanding that business is not only about profits and 'the bottom line.'

SOCIAL LICENCE IN THE MINING INDUSTRY

- 10.3 A social licence to operate (as opposed to a legal licence) has been defined as a 'set of concepts, values, tools and practices that represent a way of viewing reality for industry and stakeholders.'⁴⁷⁹ Put more practically, its purpose is to create a 'forum for negotiation' where parties involved can be heard and meaningfully involved in decisions made. Respect is a central element of these interactions, as is accountability, credibility and flexibility.⁴⁸⁰
- 10.4 The Committee notes that a recent CSIRO report that analysed Australian attitudes to mining found that Australians broadly accept mining, with a reasonably positive

⁴⁷⁸ New Zealand, Parliamentary Commissioner for the Environment, *Drilling for oil and gas in New Zealand: Environmental oversight and regulation*, June 2014, p 34.

⁴⁷⁹ J Nelsen, 'Social license to operate', *International Journal of Mining, Reclamation and Environment*, Vol. 20, No. 3, September 2006, p 161.

⁴⁸⁰ *Ibid*, p 161.

acceptance of the industry.⁴⁸¹ The same survey, however, revealed a low level of trust of the industry and regulators amongst the community.⁴⁸² According to the CSIRO:

*trust in the industry is a strong predictor of acceptance of industry. Put another way, the industry's social licence is facilitated by the level of trust that the Australian public have in it.*⁴⁸³

- 10.5 The Committee has jointly formed the view that the future exploitation of unconventional gas resources in Western Australia will rely on the notion of recovery being socially acceptable as well as economically and geologically possible.
- 10.6 Through its inquiries, the Committee has found that it is imperative to engage with affected communities early in the process of developing an unconventional gas industry in a region. Operators and regulators must be informative, upfront and candid when consulting with affected communities. The length of time that the development of onshore gas projects can take and ongoing responsibilities to rehabilitate land means that the public must be listened to and involved, even if decisions are made which cannot be changed.

Finding 48: The Committee finds that ongoing consultation with the community is essential for a continued social licence to exist, as the nature of unconventional gas development is such that one-off consultation is ineffective.

ENGAGING WITH THE COMMUNITY

- 10.7 The CSIRO refers to a social licence as being the responsibility of both government and industry 'working together with communities to promote effective, constructive and mutually beneficial relationships.'⁴⁸⁴ The more information that is provided to the community, the more likely that those mutually beneficial relationships will develop, with a 'wealth of information out there so that when a debate is going on, it is a debate about the facts, not about unknowns.'⁴⁸⁵
- 10.8 In the course of its inquiries, it has become apparent to the Committee that industry must do more to truly consult effectively in order to address community concerns. It is essential that industry commits to providing more than merely scientific information

⁴⁸¹ Commonwealth Scientific and Industrial Research Organisation, *Australian attitudes to mining – citizen survey – 2014 results*, September 2014, p 3.

⁴⁸² Ibid, p 11.

⁴⁸³ Ibid, p 14.

⁴⁸⁴ Ibid, p 15.

⁴⁸⁵ Mr John Cotter, Chairman, GasFields Commission Queensland, *Transcript of Evidence*, 12 September 2014, p 2.

to the community: operators must foster trust through early and wide-ranging engagement.

10.9 DMP submitted to the Committee that:

*as a government department that regulates this sector, we have not previously put a lot of time into actually being actively out there in those regional communities, but in the last two years, we have had a very intensive rolling program of getting out there that we have a responsibility as the regulator to be getting information to those communities about how the industry would be regulated, and also requirements on industry about how they work with their local communities.*⁴⁸⁶

Buru Energy Limited in the Canning Basin: a current, local case study

10.10 The Committee has had the opportunity to learn from Buru Energy Limited (**Buru Energy**) about its program of community engagement in the Canning Basin, including environmental cadetships and meetings with traditional owners of the land.

10.11 Thirty-two communities in the Kimberley were involved in consultation, including some who were not directly affected by Buru Energy's exploration plans, but had family members who were. Buru Energy has dedicated staff involved in community engagement and has organised one-on-one and group meetings with the community and in schools. The company also sponsors various awards and sporting events.⁴⁸⁷ The Committee notes that this is also part of developing a social licence.

10.12 The Yawuru people are the traditional owners of approximately 530 000 hectares of Yawuru country around Broome and the areas covering the Roebuck Plains and Thangoo pastoral leases in the Kimberley. This includes land above the shale gas plays of the Canning Basin. The Committee met with representatives of the Yawuru people⁴⁸⁸ and has learned that Buru Energy has been negotiating with the traditional owners for several years.

10.13 There are currently two operational gas wells owned by Buru Energy which are situated on Yawuru country: Yulleroo 3 and Yulleroo 4. The Committee has heard of

⁴⁸⁶ Ms Michelle Andrews, Deputy Director General Strategic Policy, Department of Mines and Petroleum, *Transcript of Evidence*, 25 August 2015, p 7.

⁴⁸⁷ Buru Energy Limited, *Helping the community*. Available at: <http://www.buruenergy.com/category/sponsorships/>. Viewed 21 May 2015.

⁴⁸⁸ Yawuru Native Title Holders Aboriginal Corporation and Nyamba Buru Yawuru Limited.

Yawuru's concerns regarding the safety of the hydraulic fracturing operations planned for these sites.⁴⁸⁹ These concerns include:

- the lack of information specific to Western Australia
- an unfamiliarity with the industry
- fears of groundwater or the land being contaminated by chemicals used during hydraulic fracturing
- a desire to be meaningfully included in the process.

10.14 The Committee notes that traditional owners need not just information, but also the tools and time for the community to come to terms with decisions being made about their country and an acknowledgement that Aboriginal cultural value systems may require a different approach.

10.15 In July 2014, members of the Yawuru Native Title Holders Aboriginal Corporation resolved to not agree to any hydraulic fracturing that may occur by Buru Energy at the two Yulleroo wells on Yawuru country. Yawuru also noted, however, that if Buru Energy went ahead with its proposed hydraulic fracturing, the company 'must agree to meet environmental, cultural, social and economic conditions set by Yawuru.'⁴⁹⁰ According to Buru Energy's response:

*the company remains fully engaged with Yawuru to ensure the agreed conditions in relation to the undertaking of its scheduled program are fully informed by the independent advisory process that Yawuru is undertaking, and is confident of maintaining a positive and mutually beneficial relationship with Yawuru.*⁴⁹¹

10.16 The Yawuru people recently entered into an Indigenous Land Use Agreement with Buru Energy for the Ungani oil production project.⁴⁹² Whilst the Ungani field will exploit oil, rather than shale gas, it is significant to note that the agreement was reached with the Yawuru people not giving their consent to any hydraulic fracturing taking place as part of the project's development.

⁴⁸⁹ Refer also to: Yawuru Expert Group, *Yulleroo 3 and 4 Hydraulic Fracturing Project Canning Basin, Western Australia: Peer Review of TGS14 Environment Plan (Rev_0, 1, 2, 3 and 4)*, July 2014. The Yawuru Expert Group engaged independent experts from Curtin University, Environs Kimberley and Dr Tina Hunter.

⁴⁹⁰ Yawuru Native Title Holders Aboriginal Corporation, Media Release, *Yawuru members make decision about fracking at Yulleroo*, 18 July 2014.

⁴⁹¹ Buru Energy Limited, *Quarterly Report: Period ended 30 June 2014*, p 3.

⁴⁹² Buru Energy Limited, ASX Release, *Approval of Final Native Title Agreement for Ungani Oil Field*, 14 April 2015.

- 10.17 Negotiations with the Yawuru people are ongoing and the process continues to evolve. The Committee will follow any future developments with interest and with the expectation that a mutually beneficial outcome can be reached in a timely manner.
- 10.18 The Committee also notes that other traditional owners in the region have successfully negotiated agreements with Buru Energy, such as the Yungngora people at Noonkanbah Station in the Kimberley. In 2014, the Yungngora community announced its support for Buru Energy to conduct tests on traditional land as part of its tight gas pilot exploration program. The Yungngora Aboriginal Corporation (YAC) stated that:

Buru Energy has engaged with YAC since 2007, when their predecessor, Arc Energy, first entered into a heritage agreement with us. Since then heritage surveys, monitoring and now independent expert reports have ensured that at every step of the way Noonkanbah has been kept informed of what is a significant program, both for Buru Energy, as well as potentially for the Noonkanbah People.

*We look forward to a positive and continuing relationship with Buru Energy.*⁴⁹³

- 10.19 Buru Energy has recently completed hydraulic fracturing operations on Yungngora land, with traditional owners again expressing support for the ongoing operations on Yungngora land, as follows:

We allowed this [hydraulic fracturing on Yungngora country] to happen after speaking to many experts about the effect of this activity on our country and the environment. Our experts looked at Buru's plans and let us know this is a safe activity if it is done properly. We trust Buru to do this properly.

*It has been great to see our young people work closely with Buru and we have that connection.*⁴⁹⁴

Community attitudes towards shale and tight gas

- 10.20 In June 2013, DMP commissioned a survey to assess the community's views and understanding of the shale and tight gas industry in Western Australia.⁴⁹⁵ DMP's telephone survey was based on a State-wide sample of 402 respondents and a further

⁴⁹³ Yungngora Association Inc and Buru Energy, Joint Media Release, *Noonkanbah supports Buru Energy tight gas exploration program*, 25 June 2014, p 3.

⁴⁹⁴ Yungngora Association Inc, *Joint Statement by Yungngora Chairwoman, Caroline Mulligan and Koolkarriya Committee Chairman, Ronnie Lormada*, 11 September 2015.

⁴⁹⁵ Department of Mines and Petroleum, *Survey: Community attitudes towards shale and tight gas*, June 2014.

200 respondents each, from the North Perth Basin, Southern Carnarvon Basin and Canning Basin.

10.21 DMP's study 'identified that location has an identifiable impact on attitudes and opinions in relation to the shale gas industry and...hydraulic fracturing.'⁴⁹⁶ There is an almost equal divide in the regional community between residents who object to the emerging shale gas industry in WA, residents who are undecided and those who support it:

- North Perth Basin:⁴⁹⁷ 30 per cent object, 35 per cent undecided, 35 per cent support.
- Southern Carnarvon Basin:⁴⁹⁸ 29 per cent object, 32 per cent undecided, 39 per cent support.
- Canning Basin:⁴⁹⁹ 28 per cent object, 38 per cent undecided, 34 per cent support.

10.22 The Committee notes that 41 per cent of all respondents across Western Australia had 'never heard of hydraulic fracturing' and another 27 per cent had heard of it, but did not know what was involved. The Committee notes that DMP has used the results of this survey to form the basis for its community engagement program and to develop its information sheets for the public.

10.23 The Committee notes that the views expressed as a result of DMP's surveys were part of the environment that existed when the Committee first resolved to commence this inquiry into hydraulic fracturing in Western Australia. The polarity of views that existed at the time and the clear divergence in community opinion were some of the factors behind the Committee's decision to commence this important inquiry.

Holding urban communities to account

10.24 The Committee has identified that it is 'critical that those [directly affected] communities have an understanding of what goes on around their communities.'⁵⁰⁰ This is an important issue for the community to understand.

⁴⁹⁶ Department of Mines and Petroleum, *Survey: Community attitudes towards shale and tight gas*, June 2014, p 1.

⁴⁹⁷ A total of 201 respondents from: City of Geraldton and surrounds, Shire of Irwin, Shire of Mingenew, Shire of Dandaragan, Shire of Gingin and the Shire of Carnamah.

⁴⁹⁸ Comprising of 196 respondents from: Carnarvon urban area and surrounding suburbs (excluding Coral Bay), Shire of Exmouth, Shire of Upper Gascoyne, Onslow suburb and the Shire of Roebourne.

⁴⁹⁹ A total of 202 respondents from: Shire of Broome (excluding Beagle Bay and La Grange Aboriginal community), Shire of Derby-West Kimberley and the Town of Port Hedland.

⁵⁰⁰ Mr John Cotter, Chairman, GasFields Commission Queensland, *Transcript of Evidence*, 12 September 2014, p 13.

10.25 John Cotter, Chairman of the GasFields Commission Queensland, advised the Committee that urban communities also have a role to play in developing a social licence to operate:

I do not think this [the development of industry] is anything new, but I think what we are dealing with differently is that we have urban communities, in particular, that know that is happening out there, they have the benefits in the city and they are more detached from it than they were 40 years ago, because everybody sort of knew someone who farmed or worked in the resource industry...I think we are not as familiar as a community about how these industries work.⁵⁰¹

Finding 49: The Committee finds that the views of those communities directly affected by hydraulic fracturing operations should hold significant weight in any decision-making related to the development of an unconventional gas industry in Western Australia.



Figure 31. Committee Members with community leaders of Dimock, Pennsylvania, USA

L-R: Hon Brian Ellis MLC, Mr Matthew Neenan, Township Supervisor, Ms Esther Rayias, Secretary Treasurer Dimock Township, Hon Stephen Dawson MLC, Hon Paul Brown MLC, Hon Samantha Rowe MLC [Source: Committee site visit, 27 May 2014]



Figure 32. Public hearing with AWE representatives, Shire of Irwin Recreation Centre, Port Denison [Source: Committee hearing, 27 October 2014]

⁵⁰¹ Mr John Cotter, Chairman, GasFields Commission Queensland, *Transcript of Evidence*, 12 September 2014, p 5.

The importance of baseline monitoring and transparency in data

10.26 In the course of this inquiry, it has been continually demonstrated to the Committee that it is fundamentally important to establish baseline data for water sources and the geology of the prospective resource area. The collection of baseline data and ongoing monitoring is also vital from a social licence perspective.

10.27 When industry has completed thorough and widespread baseline monitoring to collect data in a prospective region, it sets up the framework for trust to be built in the community. It also provides a legal basis for that trust, such that any incidents of contamination can be investigated and compared to the baseline figures. ACOLA recognises the importance of baseline monitoring and advises that:

*Measurement of natural background levels of methane in groundwater unrelated to shale gas extraction to establish a baseline is important to remove ambiguity...It is important to recognise that ground waters and surface waters can contain natural contaminants, such as metals and hydrocarbons. Therefore it is important to have a baseline survey to determine natural levels of contamination and also natural variability.*⁵⁰²

10.28 The Committee notes that issues such as chemical disclosure are important to the community and so industry needs to balance its need for commercial confidentiality with the trust of a community, as:

*public concern over increased competition and impacts on freshwater availability can threaten a company's social license [sic] to operate and lead to changes in government regulations that could impact both short-and long-term investments.*⁵⁰³

Finding 50: The Committee finds that baseline monitoring of water sources and local geology is fundamentally important, not only for scientific purposes, but also to establish a successful social licence for unconventional gas development.

Finding 51: The Committee finds that transparency in data and effective communication to the public of information related to hydraulic fracturing is vital to establish a successful social licence for unconventional gas development.

⁵⁰² ACOLA Report, p 172.

⁵⁰³ World Resources Institute, *Global Shale Gas Development: Water Availability and Business Risks*, Washington, 2014, p 8.

Recommendation 12: The Committee recommends that any future consideration of hydraulic fracturing for unconventional gas in Western Australia be based on established facts, ascertained through baseline data and monitoring, with a view to strengthening the industry's social licence to operate.

CHAPTER 11

CONCLUSION

I think in public office, we have the opportunity to make a contribution to not only our own state, but to the nation as a whole, and if we can do that sharing our experiences, I think that this is a benefit to all.

Mr John Cotter, Chairman, GasFields Commission Queensland⁵⁰⁴

- 11.1 The emergence of technologies to extract shale gas continues to have a profound effect on the dynamics of the international petroleum industry. In turn, this has created new challenges for all affected by the phenomenon: from individual land owners to local communities and provincial and national governments.
- 11.2 The Committee recognises the potential benefits of a shale gas industry as an employer, an investment generator and a provider of future energy security.
- 11.3 Western Australia has a reputation as an industry leader in mining and petroleum extraction and there has been much anticipation that unconventional gas will be a major feature of the State's future development. It is perhaps a surprise to many that Western Australia, with its extensive reserves of shale gas, has not yet experienced the dramatic growth of the industry seen in other jurisdictions, most notably the USA.
- 11.4 Whether (or when) a substantial shale gas industry arises in Western Australia remains to be seen but it is likely, in any case, that Western Australia's regulators will receive further applications for exploration and development.
- 11.5 At every stage, the Western Australian community will expect – as it should – that those matters will be dealt with by Government in a manner that ensures that any development which does proceed will do so in a manner which safeguards the wellbeing of our people and the environment we live in.
- 11.6 In the course of this inquiry, the Committee has examined relevant agencies, in some cases on numerous occasions. The Committee has a high level of confidence that the State's regulators are committed to, and competent in, their respective roles. However, the Committee has made a number of specific recommendations in this report intended to assist regulatory agencies to deliver the safeguards required.

⁵⁰⁴ Mr John Cotter, Chairman, GasFields Commission Queensland, *Transcript of Evidence*, 12 September 2014, p 1.

- 11.7 Notwithstanding anything in this report, it remains likely that the issue of hydraulic fracturing for unconventional gas will continue to be the subject of public debate.
- 11.8 As stated in this report's introduction, it was the purpose of this inquiry to provide a body of factual information which will help the Parliament of Western Australia, future decision makers and the public in their contemplation of this area of activity.



Hon Simon O'Brien MLC
Chairman

17 November 2015

APPENDIX 1

SUBMISSIONS RECEIVED

No.	Submitter	Date of submission
1	The Country Women's Association of Western Australia (Inc.)	15/08/13
2	Mary Sturmer	18/08/13
3	Andrew Smart	18/08/13
4	Julian Sharp	23/08/13
5	Simone McInnes	25/08/13
6	John Clark	04/09/13
7	The Wilderness Society (WA) Inc.	05/09/13
8	Susannah Shields	05/09/13
9	Audrey Neale	09/09/13
10	Amanda Rowland	10/09/13
11	Steve Gilman	12/09/13
12	Tony Lambert (Cervantes Lodge)	12/09/13
13	Steve Trafford	12/09/13
14	Anthony Palmer	16/09/13
15	Gary Fuller	16/09/13
16	Robyn Watts	17/09/13
17	Regnan Governance Research & Engagement Pty Ltd	17/09/13
18	Nick Tsurikov	17/09/13
19	Rose Holdaway	17/09/13
20	Leonie Stubbs	17/09/13
21	Buru Energy Limited	18/09/13
22	Vaughan Ujdur	17/09/13
23	Roy Oldham	17/09/13
24	Erica Brock	18/09/13
25	Marie Macdonald	18/09/13
26	Power Eneabba	18/09/13
27	Eileen Whitehead	11/09/13
28	Patricia McAuliffe	17/09/13
29	Paul Loring	18/09/13
30	Guy Tunbridge	18/09/13
31	Nathalie Haymann	18/09/13
32	Sandra Reed and Nigel Rice	18/09/13
33	Cape Conservation Group Inc.	18/09/13
34	Public Health Association Australia (WA Branch)	20/09/13
35	Susan Brown	18/09/13
36	John Daw	18/09/13
37	Peter Mack	18/09/13

38	Private citizen	19/09/13
39	UIL Energy	19/09/13
40	Environmental Health Australia (Western Australia) Incorporated	18/09/13 and 26/03/14
41	Brenda McAuliffe Poznik	19/09/13
42	Celia Lee	18/09/13
43	Sven Borg	18/09/13
44	Graeme Eddington	18/09/13
45	Kent Heard	19/09/13
46	Adriana Pracas	18/09/13
47	Water Corporation	19/09/13
48	Dr Valerie van Loggerenberg	19/09/13
49	Dr Gregory Glazov	19/09/13
50	Alliance for a Clean Environment Inc.	19/09/13
51	Patricia Gallaher	19/09/13
52	Rachel Tenni	19/09/13
53	Dan Clarke	19/09/13
54	Angus King	19/09/13
55	Gingin Water Group Inc.	19/09/13
56	Frack Free Geraldton	19/09/13
57	Christine Elsasser	20/09/13
58	Bronwyn Scallan	19/09/13
59	Paul Scallan	19/09/13
60	John Hakesley	20/09/13
61	David and Joan Cook	20/09/13
62	Craig Phillips	20/09/13
63	Sustainable Energy Now, Inc.	20/09/13
64	Andrew Thompson	20/09/13
65	Tony Lambert (Cervantes Lodge)	20/09/13
66	Anglican EcoCare Commission	20/09/13
67	Hon Robin Chapple MLC	20/09/13
68	Judith Blyth	19/09/13
69	Aimee Carson	18/09/13
70	Cliff Harris	24/09/13
71	Alison Farmer	17/09/13
72	Judith Cullity	20/09/13
73	Lisa Smith	20/09/13
74	Christine and Kingsley Smith	20/09/13
75	Clint Warn	17/09/13
76	No Fracking WAY	17/09/13
77	Rebecca and Glen Mackin	12/09/13
78	Tamboran Resources Ltd	20/09/13
79	Australian Academy of Technological Sciences and Engineering	20/09/13

80	Eric, Richard and Mary Holmes	20/09/13
81	Mandy Juniper	20/09/13
82	John Budge	19/09/13
83	Ronda Harman	16/09/13
84	Dean Leggo	20/09/13
85	Brett Woodroffe	20/09/13
86	Meegan Overstone	20/09/13
87	Doctors for the Environment Australia Inc. (SA)	20/09/13
88	Shirley Collins	20/09/13
89	Georgia Scott	20/09/13
90	Ian James	13/08/13
91	Dr Ann-Maree Lynch Calnan	20/09/13
92	Claire Bettington	20/09/13
93	Farida Iqbal	20/09/13
94	Sharon Ogle	20/09/13
95	Nyamba Buru Yawuru Ltd	20/09/13
96	Galen White	20/09/13
97	Lock the Gate Alliance	20/09/13
98	Environs Kimberley	20/09/13
99	Ron Morris	20/09/13
100	General Electric (Australia and New Zealand)	20/09/13
101	Deborah Weymouth	19/09/13
102	Kerry Grant	18/09/13
103	Ruth Mouchemore	20/09/13
104	APPEA	03/10/13
105	Department of Mines and Petroleum	03/10/13
106	Halliburton Australia Ltd	04/10/13
107	WA Department of Health	04/10/13
108	Shane Love MLA, Member for Moore	03/10/13
109	Santos Ltd	04/10/13
110	Conservation Council of Western Australia (Inc.)	04/10/13
111	New Standard Energy Ltd	04/10/13
112	The Chamber of Minerals & Energy of WA	04/10/13
113	AWE Limited	07/10/13
114	ConocoPhillips	09/10/13
115	Department of Water	09/10/13
116	The Commercial Egg Producers' Association of WA Inc.	06/03/14
117	Environmental Protection Authority	25/03/14

APPENDIX 2

HEARINGS

Date	Witnesses
7 February 2014	Mr Piers Verstegen, Director, Conservation Council of Western Australia (Inc.)
	Mr Tadas Bagdon, Executive Director, Policy and Innovation, Department of Water
	Mr Nigel Mantle, Manager, Water Source Protection Planning, Department of Water
	Mr Scott Macaulay, Senior Hydrogeologist, Department of Water
	Mr Stedman Ellis, Chief Operating Officer, Western Region, Australian Petroleum Production and Exploration Association Mr Andrew Taylor, Senior Policy Advisor, Australian Petroleum Production and Exploration Association
10 February 2014	Mr Ashley Vincent, General Manager, Planning and Capability Group, Water Corporation
	Dr Steve Capewell, Manager, Drinking Water Quality, Water Corporation
	Mr David Guglielmo, Country Manager, Halliburton Australia Ltd
17 February 2014	Professor Tarun Weeramanthri, Executive Director, Public Health, Department of Health
	Dr Martin Matisons, Principal Toxicologist, Department of Health
	Mr Richard Sellers, Director General, Department of Mines and Petroleum Dr Phil Gorey, Executive Director Environment, Department of Mines and Petroleum
	Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum
	Mr Steven Gilman
12 March 2014	Dr Emma Croager, President, Public Health Association of Australia, WA Branch
	Ms Jessamie Godsell, Advocacy Committee Member, Public Health Association of Australia, WA Branch
31 March 2014	Dr Paul Vogel, Chairman, Environmental Protection Authority
	Mr Colin Cruickshank, General Manager, Unconventional Resources and Exploration, Santos Ltd
	Mr Nicholas Fox, Chief Environmental Manager, Santos Ltd
	Mr Matthew Doman, Manager, Public Affairs Eastern Australia, Santos Ltd
	Mr George Chadwick, Board Director, Environmental Health Australia (Western Australia) Mr Mark Canny, Climate Change Coordinator, City of Greater Geraldton

12 September 2014	Mr John Cotter, Chairman, GasFields Commission Queensland Mr Jeffrey Haworth, Executive Director Petroleum, Department of Mines and Petroleum
27 October 2014	Councillor Stuart Chandler, President, Shire of Irwin Mr Darren Simmons, Chief Executive Officer, Shire of Irwin
<i>Shire of Irwin Recreation Centre, Port Denison, WA</i>	Councillor Damien Rackemann, President, Shire of Coorow Mr Darren Friend, Chief Executive Officer, Shire of Coorow
	Mr Bruce Clement, Managing Director, AWE Ltd Mr Mark Fabian, Subsurface Manager, Onshore Western Australia, AWE Ltd
	Mr Eric Holmes, farmer Mr Ray Hortin, Chairman, POWER Eneabba
25 August 2015	Mr Richard Sellers, Director General, Department of Mines and Petroleum Ms Michelle Andrews, Deputy Director General, Strategic Policy, Department of Mines and Petroleum

APPENDIX 3

SITE VISITS AND TRAVEL

Date	Details of meeting
24-25 March 2014 <i>Broome, WA</i>	Mr Martin Pritchard, Executive Director, Environs Kimberley Ms Caitlin Pilkington, Freshwater Project Officer, Environs Kimberley
	Yawuru Native Title Holders Aboriginal Corporation (PBC) and Nyamba Buru Yawuru (NBY) representatives
	Mr Jon Ford, General Manager Community Relations, Buru Energy Ltd Dr Damian Ogburn, Chief Scientist, Buru Energy Ltd Ms Regina Titelius, Media Adviser, Buru Energy Ltd
	Councillor Graeme Campbell, President, Shire of Broome Mr Andries Schonfeldt, Director Development Services, Shire of Broome
17 May-4 June 2014 <i>London, UK</i> <i>Nottingham, UK</i> <i>New York City, USA</i> <i>Washington DC, USA</i> <i>Dimock County, USA</i> <i>Austin, USA</i>	Professor Robert Mair CBE FREng FRS, Chair Working Group, The Royal Society/The Royal Academy of Engineering, UK Mr Ben Koppelman, Senior Policy Adviser, Science Policy Centre, The Royal Society, UK
	Mr Tim Yeo MP, Chair, Energy and Climate Change Committee, House of Commons, UK
	Mr David TC Davies MP, Chair, Welsh Affairs Committee, House of Commons, UK
	Professor David MacKay, Chief Scientific Advisor, Department of Energy and Climate Change, UK Mr Duarte Figueira, Head – Office of Unconventional Gas and Oil, Department of Energy and Climate Change, UK
	Mr Reg Platt, Senior Research Fellow, Institute of Public Policy Research, UK
	Professor Richard Davies, Dean of Knowledge Exchange and Impact, Durham University, UK
	Mr Ed Hough, Geologist, British Geological Survey, UK Dr Robert Ward, Director of Science – Groundwater, British Geological Survey, UK Dr Brian Baptie, Earthquake Seismology, British Geological Survey, UK
	Mr Bill desRosiers, External Affairs Coordinator, Cabot Oil & Gas Corporation, USA
	Ms Esther Rayias, Secretary, Dimock Township, USA Mr Matthew Neenan, Town Supervisor, Dimock Township, USA

	<p>Professor Anthony Ingraffea, Dwight C Baum Professor of Engineering, Director Cornell Fracture Group, Cornell University, USA</p> <p>Professor Madelon Finkel, Professor of Healthcare Policy and Research, Director Office of Global Health Education, Weill Cornell Medical College, USA</p> <p>Ms Jeanne Briskin, Hydraulic Fracturing Research Coordinator, Office of Science Policy, Office of Research and Development, Environmental Protection Agency, USA</p> <p>Mr William Bates, Geologist, Environmental Protection Authority, USA</p> <p>Ms Katherine Buckley, Acting Senior Advisor, Office of International and Tribal Affairs, Environmental Protection Agency, USA</p> <p>Ms Sally Kornfeld, Team Leader, International Oil and Gas Activities, Department of Energy, USA</p> <p>Mr Sam Beatty, Industry Analyst, Office of Oil and Natural Gas, Department of Energy, USA</p> <p>Mr David Porter, Commissioner, Railroad Commission of Texas, USA</p> <p>Mr Milton Rister, Executive Director, Railroad Commission of Texas, USA</p> <p>Mr Gil Bujano PE, Director, Railroad Commission of Texas, USA</p> <p>Mr Ramon Fernandez Jr PE, Deputy Director Field Operations, Railroad Commission of Texas, USA</p> <p>Ms Gaye Greever McElwain, Public Outreach Information Officer, Railroad Commission of Texas, USA</p>
<p>2-4 September 2014 <i>Adelaide, SA</i> <i>Moomba, SA</i></p>	<p>Mr Barry Goldstein, Executive Director, Energy Resources Division, Department of State Development, SA</p> <p>Mr Colin Cruickshank, General Manager – Unconventional Resources & Exploration, Eastern Australia Business Unit, Santos Ltd, SA</p> <p>Mr Tom Baddeley, Manager Government & Community Relations, WA & NT Business Unit, Santos Ltd, WA</p> <p>Mr Javier (Yub) Fernandez, Eastern Australia Drilling Superintendent, Santos Ltd, SA</p> <p>Mr Rohan Richardson, Eastern Australia Drilling and Completions Manager, Santos Ltd, SA</p> <p>Mr Matt Rohrlach, Operating Company Representative Fracture Stimulation, Eastern Australia Drilling and Completions, Santos Ltd, SA</p>

28 October 2014 <i>Port Denison, WA</i> <i>Irwin, WA</i> <i>Green Head, WA</i>	Mr Eric Holmes, farmer, WA Mr Richard Holmes, farmer, WA
	Mr Bruce Clement, Managing Director, AWE Limited, NSW Ms Jane Aberdeen, Environmental and External Affairs Consultant, AWE Limited, WA Mr Mark Fabian, Subsurface Manager, AWE Limited, WA Mr Darrell Girgenti, Project Manager, AWE Limited/Norwest Energy, WA Mr Cameron Morse, Senior Director, FTI Consulting, WA

APPENDIX 4

SUMMARY OF AUSTRALIAN AND INTERNATIONAL REPORTS

Australian reports

The Economics and Industry Standing Committee of the Legislative Assembly commenced an inquiry into the economic impact of floating liquefied natural gas⁵⁰⁵ on Western Australia on 23 May 2013. That committee's inquiry relates to the impact of the offshore gas industry on the Western Australian economy, domestic gas supply and impact on State revenue.⁵⁰⁶

This Committee's inquiry considers environmental issues related to hydraulic fracturing in Western Australia, therefore avoiding duplication or overlap. This inquiry will not deal with issues related to domestic gas supply or the economics of the onshore gas industry.

The Committee notes also that the final report of that committee was tabled in the Legislative Assembly on 15 May 2014 and recommends that report to those parties interested in the economic implications of onshore and offshore gas.

ACOLA published its report into shale gas in Australia in May 2013: 'Engineering Energy: Unconventional Gas Production.'⁵⁰⁷ The ACOLA Report was one of the first impartial, evidence-based reviews of the Australian shale gas industry and has been referred to during several of the Committee's hearings held in 2014. In this report, the Committee will expand upon some of the recommendations put forward in the ACOLA Report with reference to WA's onshore shale gas industry.

On 6 March 2014, the Northern Territory government appointed Dr Allan Hawke AC to inquire into hydraulic fracturing in the Northern Territory.⁵⁰⁸ That inquiry's terms of reference covered similar areas of concern as this inquiry, including an assessment of the environmental risks and actual environmental impacts of hydraulic fracturing in the Northern Territory and the effectiveness of mitigation measures.⁵⁰⁹ The Committee notes that the significant community interest in the Commissioner's inquiry reflects the high level of engagement that this Committee has seen throughout the course of its inquiry in our State. The Commissioner presented his final report to the Northern Territory Government on 28 November 2014. The

⁵⁰⁵ 'Floating liquefied natural gas' is natural gas which is found offshore under the seabed. The gas is extracted, processed and chilled ('liquefied') by a floating processing facility moored offshore.

⁵⁰⁶ Western Australia, Legislative Assembly, Economics and Industry Standing Committee, Report 2, *The economic impact of floating LNG on Western Australia*, 15 May 2014.

⁵⁰⁷ 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.

⁵⁰⁸ *Inquiries Act* (NT) s 4(1).

⁵⁰⁹ The terms of reference for that inquiry are available at: http://www.hydraulicfracturinginquiry.nt.gov.au/terms_of_reference.html. Viewed 13 November 2014.

Northern Territory Government tabled the report in the Parliament of the Northern Territory on 27 February 2015.⁵¹⁰

International reports

The Committee acknowledges several important international studies conducted by key agencies and statutory authorities which have informed this report.

In June 2015, the United States Environmental Protection Authority released a draft report containing the findings of its long-term study into the effect of hydraulic fracturing technology on drinking water resources. The research project, commenced in 2010, included programs such as FracFocus⁵¹¹, detailed case studies and state-of-the-science data and scientific literature, giving the study ongoing relevance and application to this inquiry. The draft report and various peer-reviewed studies are available from the United States Environmental Protection Authority's website.⁵¹²

'Shale Gas extraction in the UK: a review of hydraulic fracturing'⁵¹³ was a joint publication by The Royal Society and The Royal Academy of Engineering in the UK in June 2012. The findings and recommendations of the report were very informative in developing the conclusions arising from this inquiry.

The British Geological Survey has released several reports documenting the potential for shale gas development in the UK. The Society's report into the Jurassic shale of the Weald Basin revealed no significant gas resource in the South-East of England, an area previously thought to represent great potential for shale gas extraction.⁵¹⁴

The International Energy Agency developed the 'Golden Rules for a Golden Age of Gas' as part of a special report on the global outlook for unconventional gas production.⁵¹⁵ The document sets best practice principles for regulators and the unconventional gas industry.

⁵¹⁰ *Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory*, Tabled Paper 1257. Also available at: <http://www.hydraulicfracturinginquiry.nt.gov.au/index.html>.

⁵¹¹ FracFocus is the United States national hydraulic fracturing chemical disclosure registry, available at: <http://fracfocus.org/>. The issue of chemical disclosure is discussed in more detail in Chapter 6 of this report.

⁵¹² US Environmental Protection Authority, *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*. Available at: <http://www2.epa.gov/hfstudy>. Viewed 13 November 2014.

⁵¹³ Royal Society and Royal Academy of Engineering, London, June 2012. Available at: <http://www.royalsociety.org/policy/projects/shale-gas-extraction> and <http://www.raeng.org.uk/shale>. Viewed 13 November 2014.

⁵¹⁴ British Geological Survey and Department of Energy & Climate Change, *The Jurassic shales of the Weald Basin: geology and shale oil and shale gas resource estimation*, 23 May 2014. Available at: <https://www.gov.uk/government/publications/bgs-weald-basin-jurassic-shale-reports>. Viewed 13 November 2014.

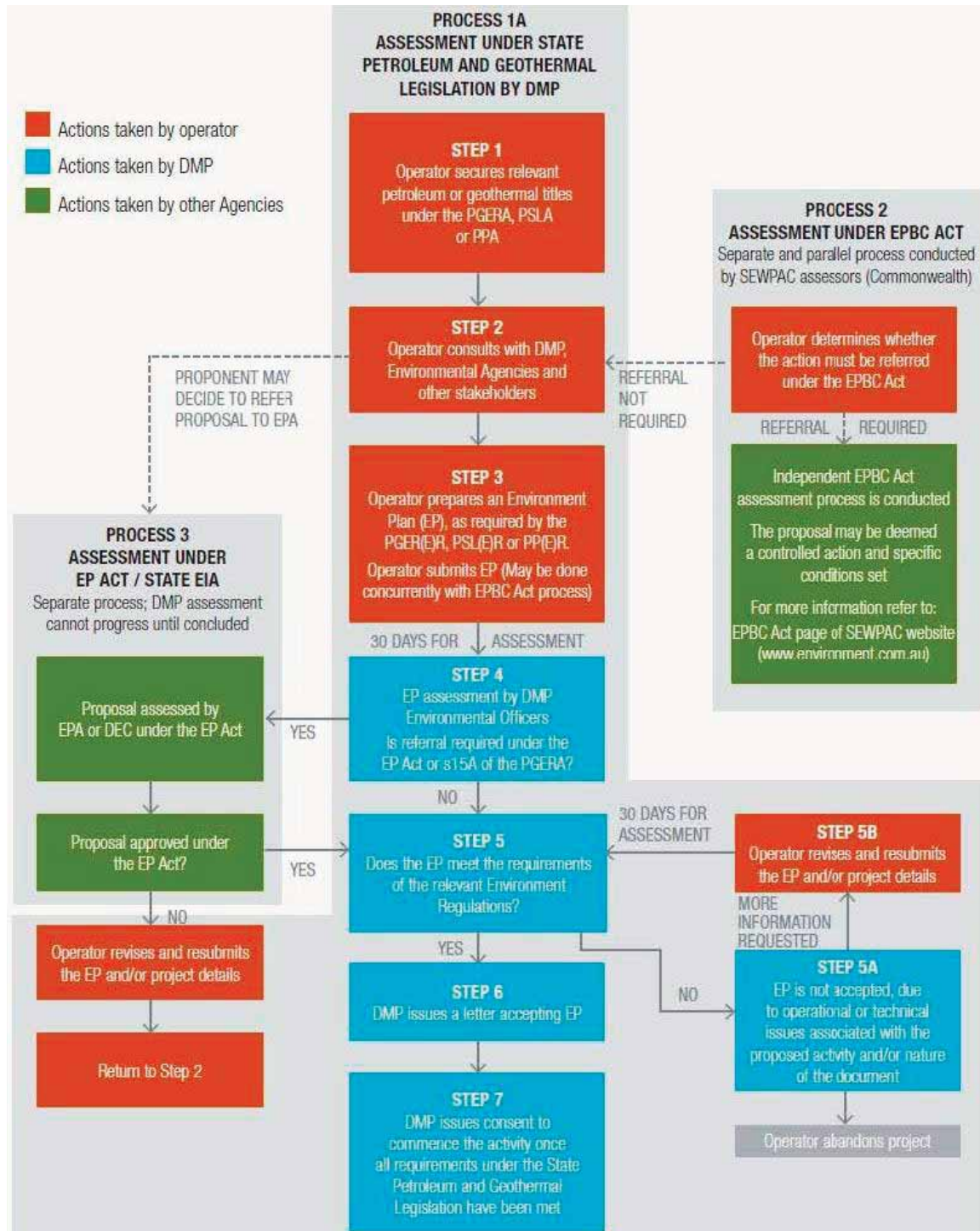
⁵¹⁵ International Energy Agency, *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*, 12 November 2012.

New Zealand's Parliamentary Commissioner for the Environment is an independent officer of Parliament whose statutory duty is to provide independent advice to Members of Parliament in their consideration of matters that may impact the quality of New Zealand's environment. The Committee has referred to the Commissioner's two reports into hydraulic fracturing: one in 2012 and the final report in June 2014.⁵¹⁶

⁵¹⁶ New Zealand, Parliamentary Commissioner for the Environment, *Drilling for oil and gas in New Zealand: Environmental oversight and regulation*, June 2014 and *Evaluating the environmental impacts of fracking in New Zealand: An interim report*, November 2012. Available at: <http://www.pce.parliament.nz>. Viewed 13 November 2014.

APPENDIX 5

ENVIRONMENT PLAN ASSESSMENT PROCESS



APPENDIX 6

KEY AGENCIES, ROLES AND LEGISLATION INVOLVED IN THE ONSHORE OIL AND GAS INDUSTRY IN WESTERN AUSTRALIA

	Agency	Role	Legislation
STATE	Department of Aboriginal Affairs	Assessment of Aboriginal heritage	<i>Aboriginal Heritage Act 1972</i>
	Department of Agriculture and Food	Assessment of environmental biosecurity issues such as pests, weeds and diseases	<i>Biosecurity and Agriculture Management Act 2007</i>
	Department of Environment Regulation	Assessment of emissions and discharges; issuing of works approvals and licences; management of contaminated sites	<i>Environmental Protection Act 1986</i> <i>Contaminated Sites Act 2003</i>
	Department of Health	Assessment of water quality in water supplies to safeguard human health	<i>Health Act 1911</i>
	Department of Mines and Petroleum	Assessment of environment plans; works program; well management plan; safety management system; safety case; native vegetation clearing permit applications	<i>Dangerous Goods Safety Act 2004</i> <i>Petroleum and Geothermal Energy Resources Act 1967</i> <i>Petroleum Pipelines Act 1969</i> <i>Petroleum (Submerged Lands) Act 1982</i> <i>Delegated authority under the Environmental Protection Act 1986 for native vegetation clearing</i>
	Department of Parks and Wildlife	Management of conservation reserve system; conserving threatened species and ecological communities	<i>Conservation and Land Management Act 1984</i> <i>Wildlife Conservation Act 1950</i>
	Department of Water	Assessment of proposed water wells and taking of water licence applications. Management of safe guarding public drinking water sources	<i>Rights in Water and Irrigation Act 1914</i> <i>Metropolitan Water Supply, Sewerage and Drainage Act 1909</i> <i>Country Areas Water Supply Act 1947</i> <i>Water Agencies (Powers) Act 1984</i>
	Environmental Protection Authority	Environmental impact assessment for proposals likely to have significant environmental impacts	<i>Environmental Protection Act 1986</i>
	Radiological Council	Assessment of naturally occurring radioactive material licence applications for storage and transport	<i>Radiation Safety Act 1975</i>
	CWLTH	Department of Environment	Environmental impact assessment for proposals likely to have an impact on matters of national environmental significance
Clean Energy Regulator		Reporting of greenhouse gas emissions	<i>National Greenhouse and Energy Reporting Act 2007</i>
National Native Title Tribunal		Assessment of Native Title claimant applications and Indigenous land use agreements.	<i>Native Title Act 1993</i>

[Source: Department of Mines and Petroleum, *Natural Gas from Shale and Tight Rocks: An overview of Western Australia's regulatory framework*, February 2014]

APPENDIX 7

HUNTER REPORT RECOMMENDATIONS AND DMP RESPONSES

Available at: http://www.dmp.wa.gov.au/documents/DMP_Response_to_Report.pdf

Recommendation	DMP Response	Current Approach	Outcome and Future Actions
<p>Recommendation 1: The Western Australian Department of Mines and Petroleum should develop a policy/strategy for the management of produced water from fracking processes. This strategy should be based on best practice, taking into (account) domestic and international experiences.</p>	Agreed	<p>DMP currently requires that each operator detail the proposed method for managing produced water², within their EMP.</p> <p>DMP has established an interagency working group to improve coordination across government to identify opportunities for strengthening policy and legislative settings and ensure DMP has access to relevant expertise.</p>	<p>DMP will publish onshore guidelines for EMPs which clarify that produced water must be addressed in detail in the EMP. This will include a requirement for the proponent to apply best practice to minimise any environmental impacts.</p> <p>DMP expects to release for stakeholder consultation, the guidelines for EMPs in parallel with the consultation for the Environment Regulations.</p> <p>The new Environment Management Regulations and EMP guidelines are expected to be released for stakeholder input by the end of 2011.</p> <p>These regulations and EMP guidelines are anticipated to be in place in 2012.</p>
<p>Recommendation 2: In implementing a management strategy for the production of shale gas, the Western Australian Department of Mines and Petroleum should ensure a produced water management plan is integrated into the whole petroleum chain, including individual well abandonment and field abandonment.</p>	Agreed	See comments for Recommendation 1, above.	<p>DMP will publish specific onshore guidelines for EMPs which clarify that produced water must be addressed in detail in the EMP. The guidelines will be prepared in consultation with the Department of Water, Environmental Protection Authority and the Department of Environment and Conservation.</p>
<p>Recommendation 3: The Western Australian Department of Mines and Petroleum should provide full, transparent disclosure of all chemicals used in WA fracking operations. This disclosure should be made available on the WADMP web site.</p>	Agreed	<p>DMP requires that companies provide in their EMPs, the Material Safety Data Sheets for the chemicals used in fracking. Existing legislation prevents DMP from publicly releasing EMPs.</p> <p>DMP is encouraging operating companies to publicly disclose EMPs and in particular chemicals used in fracking.</p>	<p>DMP will continue to require that chemicals used in fracking are included in EMPs, and will propose legislative amendments to allow DMP to publish approved EMPs on its website, while protecting personnel and commercially sensitive information.</p>

Recommendation	DMP Response	Current Approach	Outcome and Future Actions
<p>Recommendation 4: The Western Australian Department of Mines and Petroleum address the issue of conflicting land use and land access in its management of shale gas operations throughout the whole petroleum chain. This should be addressed through</p> <p>1. Legislative provisions contained within the PAGERA (objects clause)</p> <p>2. A pre-emptive land use management strategy developed in consultation with relevant stakeholders and communities.</p>	<p>1. Not Agreed</p> <p>2. Agreed (in part)</p>	<p>1. It is not the practice in Western Australia to include objects⁶ clauses in legislation.</p> <p>2. DMP will continue to ensure that industry exercises its responsibilities when dealing with landholders while recognising that petroleum in Western Australia is considered a strategic resource, and that landholders are legally entitled to compensation for actual losses incurred. Petroleum operators are also required under the PAGERA not to cause undue harm in the conduct of their operations.</p>	<p>1. The proposed Resource Management and Environment Management Regulations currently being drafted will avoid the need for objects clauses within the Act.</p> <p>2. DMP together with the WA office of APPEA, are encouraging petroleum title holders to constructively engage landholders and the community throughout the life of a project.</p>
<p>Recommendation 5: The Schedule of Onshore Exploration and Production Requirements – 1991 should be amended to include the appropriate definition of 'formation' or the like to encompass shale gas formations yielding a gas.</p>	<p>Agreed (in principle)</p>	<p>DMP currently applies a broad interpretation of the Schedule that considers 'formations' to include any body that will yield gas. This interpretation includes shale gas.</p>	<p>DMP will include in the new Resource Management Regulations (currently being drafted) an appropriate definition of the gas source 'formation'.</p> <p>These regulations are expected to be released for stakeholder input by mid 2012.</p> <p>The new regulations are anticipated to be in place in 2012.</p>
<p>Recommendation 6: The Western Australian Department of Mines and Petroleum address the issue of field sterilisation use in its management of shale gas operations throughout the whole petroleum chain. The optimal recovery of resources should be included as an objects clause in PAGERA.</p>	<p>Agreed (in part)</p>	<p>Presently, field development plans incorporate field sterilisation issues along with the optimum recovery of the resource. It is not the practice in Western Australia to include objects clauses in legislation.</p>	<p>DMP is preparing new Resource Management Regulations which will specifically address field sterilisation⁷ issues. The new Resource Management Regulations are expected to be released for stakeholder input by mid 2012.</p> <p>These new Resource Management Regulations will avoid the need for objects clauses. In Western Australia to include objects clauses in legislation.</p>

Recommendation	DMP Response	Current Approach	Outcome and Future Actions
<p>Recommendation 7: The Western Australian Department of Mines and Petroleum Safety Branch, in conjunction with the Petroleum Division, undertake an internal assessment of the Safety process to ensure that there are complementarities and the current safety regulations apply across the petroleum chain for onshore shale gas activities.</p>	<p>Agreed</p>	<p>The Western Australian Government through DMP has committed to overhauling the way safety and health in the resources industry is regulated.</p> <p>A specific program (Reform and Development at Resources Safety - RADARS) is in place to progress safety management across the resources sector. RADARS information is available online at http://www.dmp.wa.gov.au/9856.aspx.</p>	<p>DMP will undertake an internal assessment of the safety process to ensure that there are complementarities and the current safety regulations apply across the petroleum chain⁶ for onshore gas activities. This will ensure the integration of regulatory measures within DMP.</p>
<p>Recommendation 8: The Western Australian Department of Mines and Petroleum undertake to write environmental regulations to regulate onshore petroleum activities, including the recovery of coal seam gas. The creation of such regulations should be a priority to ensure enforceability of the Environmental Management Plan.</p>	<p>Agreed</p>	<p>The DMP has already prioritised the finalisation of these onshore environmental regulations.</p>	<p>The new Environment Management Regulations are expected to be released for stakeholder input by the end of 2011.</p> <p>These regulations are anticipated to be in place in 2012.</p>
<p>Recommendation 9: The WADMP undertake to plan for succession, in the Resources Branch of the Petroleum Division, including the capture of the knowledge and experience of senior petroleum engineers, geologists and geophysicists.</p>	<p>Agreed</p>	<p>A new senior management role has been created and filled in the Petroleum Division. DMP has also engaged an external human resources advisor to assist in the identification of future skill requirements, and a retention and recruitment strategy for the Division.</p>	<p>The review by the human resources consultant will identify any skills needs and provide strategies for improved succession planning and retention of technical knowledge. This review will be concluded by November 2011.</p>
<p>Recommendation 10: The WADMP undertake to write resource regulations to regulate onshore petroleum activities, including the recovery of coal seam gas.</p>	<p>Agreed</p>	<p>DMP is preparing regulations to cover all oil and gas resources including the recovery of coal seam gas. These new Resource Management Regulations are to provide greater transparency, certainty and enforcement provisions.</p>	<p>The new Resource Management Regulations are expected to be finalised following stakeholder input by mid 2012.</p> <p>These regulations are anticipated to be in place in 2012.</p>
<p>Recommendation 11: The WADMP undertake to capture in written form well design, history and experience to ensure that this information is committed to corporate memory.</p>	<p>Agreed (in principle)</p>	<p>DMP currently maintains a detailed, publicly available well data system in DMP's online Petroleum and Geothermal Information System (WAPIMS).</p> <p>All well designs from planning to completion/abandonment are submitted for approval to DMP and these are stored in the DMP Records Manager system.</p>	<p>The high standard of WAPIMS data and records management will be maintained.</p>

Recommendation	DMP Response	Current Approach	Outcome and Future Actions
<p>Recommendation 12: The WADMP ensure the inclusion of management of produced water from abandoned wells in any proposed Environment Regulations and the Resource Management Regulations.</p>	<p>Agreed</p>	<p>EMPs are currently required to identify any potential environmental effects the proposed activities may have, and provide the procedures to manage, monitor and mitigate potential incidents.</p>	<p>The appropriate control for produced water management will be included in the new Environment Management and Resource Management Regulations. This will cover activities of well abandonment.</p> <p>DMP will publish specific onshore guidelines for EMPs, which clarify that produced water must be addressed in detail in the EMP. The guidelines will be prepared in consultation with the Department of Water, Environmental Protection Authority and the Department of Environment and Conservation.</p> <p>The new Environment Regulations will be released for stakeholder input by end of 2011, and Resource Management Regulations and guidelines are expected to be released for stakeholder input by mid 2012. Both regulations and guidelines are anticipated to be in place in 2012.</p>
<p>Recommendation 13: The PAGERA requires amendment to incorporate field abandonment. The requirements for field abandonment should also be incorporated into the proposed Environment Regulations and the Resource Management Regulations.</p>	<p>Agreed</p>	<p>DMP is drafting regulations that will cover requirements for field abandonment.</p>	<p>Field abandonment will be included in the new Resource Management Regulations and Environment Regulations.</p> <p>The new Environment Regulations will be released for stakeholder input by end of 2011, and Resource Management Regulations and guidelines are expected to be released for stakeholder input by mid 2012. Both regulations and guidelines are anticipated to be in place in 2012.</p>
<p>Recommendation 14: The WADMP develop a standard Petroleum and Land Access process overview for the abandonment of a field.</p>	<p>Agreed</p>	<p>Current onshore regulations and procedures administered by DMP mirror offshore petroleum legislation decommissioning guidelines. The process has been developed and added to the Petroleum Quality Management System. DMP is in the process of strengthening regulations to cover field abandonment.</p>	<p>New Resource Management and the Environment Management Regulations will address onshore decommissioning through a field lifecycle process (petroleum exploration, development, production and decommissioning). An overview of this process will be provided upon the completion and implementation of the new Resource Management Regulations, and Environment Management Regulations.</p>
<p>Recommendation 15: The WADMP should maintain vigilance in the processes, standards and number of applications in relation to shale gas extraction to ensure that a LNG Enforcement Unit is established if required.</p>	<p>Agreed (in principle)</p>	<p>DMP undertakes environment and safety compliance auditing of activities as part of its regulatory role.</p> <p>In addition, reporting of operational and environmental performance is required of proponents.</p>	<p>DMP will continue to undertake a robust approach and commit resources to ensure compliance through auditing, inspections and enforcement.</p> <p>If WA shale activity is significantly large, DMP would consider undertaking a task-force approach to coordinate regulation across government agencies.</p> <p>DMP has an existing enforcement unit and enforcement procedures to address non-compliance. DMP does not propose to replicate the Queensland LNG Enforcement Unit, which monitors coal seam gas (CSG) operators in that state as these functions are already undertaken by DMP as Lead Agency.</p>

APPENDIX 8

MEMORANDUM OF UNDERSTANDING: CRITERIA FOR REFERRAL OF ONSHORE PETROLEUM ACTIVITIES

Schedule 2

CRITERIA FOR REFERRAL OF ONSHORE PETROLEUM ACTIVITIES

This schedule should be read in conjunction with parts 4 and 5 of this MoU

Significance Test: DMP will consult with the Office of the EPA on any proposal considered likely to have a significant impact using the following test of significance:

- Character of the receiving environment;
- Magnitude, extent and duration of anticipated change;
- Resilience of the environment and its ability to cope with change;
- Confidence of prediction of change;
- Existence of environmental values, policies, guidelines and standards against which a proposal can be assessed; and
- Degree of public interest in environmental issues likely to be associated with the proposal.

Irrespective of the outcomes of the Significance Test, DMP will take the actions as described in criteria 1-7 contained in the table below for Proposals that meet those circumstances.

		Action Taken
1	Wholly or partly within 500m of areas identified or protected under statute; <ul style="list-style-type: none"> • National Park • Nature Reserve • Conservation Park • State Forest and Timber Reserves • Threatened Ecological Communities 	DMP will refer the Proposal to the EPA in accordance with S38(5) of the EP Act 1986
2	Wholly or partly within 500m of the following areas: <ul style="list-style-type: none"> • World Heritage Property; • Biosphere Reserve, • Soil reference site, • Ramsar wetlands, • ANCA wetlands, • Sites visited by species listed under JAMBA or CAMBA. 	
3	Likely to have a direct or indirect effect upon environmentally significant lakes and wetlands including: <ul style="list-style-type: none"> • EPP lakes and wetlands; and • Conservation category wetlands. 	DMP will liaise with the Office of the EPA on the Proposal
4	Wholly or partly within 2km of the coastline	
5	Likely to impact to a water resource area, including a water reserve, a declared or proposed water supply catchment area or groundwater protection area	
6	Area currently subject to formal assessment by the EPA	
7	Wholly or partly within 2 kilometres of a declared occupied town site	DMP will refer the Proposal to the EPA in accordance with S38(5) of the EP Act 1986

Notes

- i. Proposals that are wholly or partly within specified reserves are forwarded by DMP to DEC in accordance with S15A of the *PGERA 1967*.
- ii. Proposals that require native vegetation clearing will be assessed in accordance with the *Environmental Protection Act 1986* and *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* which are covered by separate administrative arrangements between DMP and DEC.
- iii. DMP will not refer a Proposal to the EPA if the Proposal is part of a Proposal that has already been assessed by the EPA, and is consistent with the conditions of the relevant Ministerial Statement.

APPENDIX 9

LAND USE COMPATIBILITY TABLE

Model Scheme Text & interpreted type of land use	P1 areas	P2 areas	P3 areas
Agriculture– extensive			
- pastoral leases	Compatible with conditions	Acceptable	Acceptable
- floriculture (non irrigated), stock grazing (excluding pastoral leases) and broad hectare cropping,	Incompatible	Compatible with conditions (see notes 11, 12)	Acceptable
Agriculture- intensive			
- aquaculture (fish, plants and crustaceans)	Incompatible	Compatible with conditions	Compatible with conditions
- orchards; production nurseries– potted plants; viticulture– wine and table grapes	Incompatible	Compatible with conditions	Acceptable
- floriculture; market gardens (see note 24); turf farms	Incompatible	Incompatible	Compatible with conditions
- hydroponic plant growing	Incompatible	Compatible with conditions	Compatible with conditions
- plant nurseries / garden centres	Incompatible	Compatible with conditions (see note 2)	Acceptable
Agro-forestry	Incompatible	Compatible with conditions	Acceptable
Amusement parlour	Incompatible	Incompatible	Acceptable (see note 1)
Animal establishment			
- animal saleyards and stockyards (see note 13)	Incompatible	Compatible with conditions (see note 2)	Compatible with conditions (see note 2)
- apiaries	Compatible with conditions	Acceptable	Acceptable
- catteries	Incompatible	Acceptable	Acceptable
- dairy sheds	Incompatible	Compatible with conditions (see notes 2, 3, 12)	Compatible with conditions (see note 3)
- dog kennels	Incompatible	Compatible with conditions	Compatible with conditions
- equestrian centres (see note 17)	Incompatible	Incompatible	Acceptable
- feedlots, intensive outdoor livestock holding	Incompatible	Incompatible	Compatible with conditions
- stables (see note 18)	Incompatible	Compatible with conditions	Acceptable
Animal husbandry- intensive			
- piggeries	Incompatible	Incompatible	Incompatible
- poultry farming - housed	Incompatible	Compatible with conditions	Compatible with conditions
Bed and breakfast (accommodating a maximum of 6 guests)	Compatible with conditions (see notes 6, 16)	Acceptable (see note 23)	Acceptable
- farm stay accommodation, rural chalets)	Compatible with conditions (see notes 6, 16)	Compatible with conditions (see note 4)	Acceptable
Betting agency	Incompatible	Compatible with conditions (see note 2)	Acceptable (see note 1)
Caravan park	Incompatible	Incompatible	Compatible with conditions (see note 1)
Caretakers dwelling	Compatible with conditions (see note 2)	Compatible with conditions	Acceptable
Car park	Incompatible	Compatible with conditions (see note 2)	Acceptable

Model Scheme Text & interpreted type of land use	P1 areas	P2 areas	P3 areas
Cemeteries	Incompatible	Incompatible	Compatible with conditions
Child care premises	Incompatible	Compatible with conditions (see note 2)	Acceptable (see note 1)
Cinema/ theatre	Incompatible	Incompatible	Acceptable (see note 1)
Civic use	Incompatible	Compatible with conditions (see note 2)	Acceptable (see note 1)
Club premises			
- sporting or recreation clubs	Incompatible	Compatible with conditions	Acceptable (see note 1)
- health centres	Incompatible	Incompatible	Acceptable (see note 1)
Community purpose			
- community halls	Incompatible	Compatible with conditions (see note 2)	Acceptable
- irrigated golf courses or recreational parks	Incompatible	Incompatible	Compatible with conditions (see note 11)
- motor-sports (permanent racing facilities)	Incompatible	Incompatible	Compatible with conditions
- public swimming pools/ aquatic centres	Incompatible	Incompatible	Compatible with conditions
- rifle ranges	Incompatible	Compatible with conditions	Acceptable
Consulting rooms	Incompatible	Compatible with conditions (see note 2)	Acceptable (see note 1)
Convenience store	Incompatible	Compatible with conditions (see note 2)	Acceptable (see note 1)
Corrective institution	Incompatible	Incompatible	Compatible with conditions (see note 1)
Educational establishment			
- community education centres, scientific research institution	Compatible with conditions (see note 2)	Compatible with conditions (see note 2)	Acceptable (see note 1)
- primary / secondary schools, tertiary education facilities	Incompatible	Incompatible	Acceptable (see note 1)
Exhibition centre	Incompatible	Incompatible	Acceptable (see note 1)
Family day care	Incompatible	Acceptable (see note 19)	Acceptable (see note 1)
Fast food outlet	Incompatible	Incompatible	Acceptable (see note 1)
Forestry (native forest/ silviculture/ tree farming)	Compatible with conditions (see note 11)	Compatible with conditions (see note 11)	Acceptable
Fuel depot (storage/ transfer)	Incompatible	Incompatible	Compatible with conditions
Funeral parlour	Incompatible	Incompatible	Acceptable (see note 1)
Home business	Incompatible	Acceptable (see note 20)	Acceptable (see note 1)
Home occupation	Compatible with conditions (see note 15)	Acceptable (see note 21)	Acceptable (see note 1)

Model Scheme Text & interpreted type of land use	P1 areas	P2 areas	P3 areas
Home office	Compatible with conditions (see note 15)	Acceptable	Acceptable
Home store	Incompatible	Compatible with conditions	Acceptable (see note 1)
Hospital	Incompatible	Incompatible	Compatible with conditions (see note 1)
Hotel (includes hotels, hostels, resorts)	Incompatible	Incompatible	Acceptable (see note 1)
Industry			
- abattoirs	Incompatible	Incompatible	Incompatible
- cottage	Compatible with conditions	Compatible with conditions	Acceptable
- drinking water treatment plant	Compatible with conditions	Compatible with conditions	Compatible with conditions
- extractive, includes construction/ mining camps (see note 10)	Compatible with conditions	Compatible with conditions	Compatible with conditions
- food processing, dairy product factories, breweries	Incompatible	Incompatible	Compatible with conditions (see note 1)
- general (chemical manufacture/ formulation, dry cleaners, dye works, laboratories, photo-processors)	Incompatible	Incompatible	Compatible with conditions (see note 1)
- general (metal production/ finishing, pesticide operator depots, heavy or energy industry, petroleum refineries)	Incompatible	Incompatible	Incompatible
- general (concrete batching, cement products, fertiliser manufacture/ bulk storage, wrecking)	Incompatible	Incompatible	Compatible with conditions
- general (mineral processing)	Incompatible	Incompatible	Compatible with conditions (see note 9)
- light industry	Incompatible	Incompatible	Compatible with conditions (see note 1)
- milk transfer depots	Incompatible	Incompatible	Compatible with conditions
- mining (includes mineral and energy exploration, oil or gas extraction / decontamination for transport)	Compatible with conditions (see note 9)	Compatible with conditions (see note 9)	Compatible with conditions (see note 9)
- mining (tailings dams)	Incompatible	Incompatible	Compatible with conditions (see note 9)
- mining (includes construction/ mining camps), (see note 10)	Compatible with conditions	Compatible with conditions	Compatible with conditions
- rural (animal product rendering works, tanneries, wool scours)	Incompatible	Incompatible	Incompatible
- rural (farm supply centres, manure stockpiling/ processing facilities)	Incompatible	Compatible with conditions (see note 2)	Compatible with conditions
- rural (forestry products processing— chip mills, pulp/ paper, timber preservation, wood/ fibre works, composting/ soil blending - commercial)	Incompatible	Incompatible	Compatible with conditions
- service industry	Incompatible	Incompatible	Compatible with conditions
Landfill (solid waste disposal)			
- class I (refer also to 'Storage - used tyres' advice)	Incompatible	Incompatible	Compatible with conditions
- class II or III	Incompatible	Incompatible	Incompatible
- class IV or V	Incompatible	Incompatible	Incompatible
Lunch bar	Incompatible	Compatible with conditions (see note 2)	Acceptable (see note 1)

Model Scheme Text & interpreted type of land use	P1 areas	P2 areas	P3 areas
Major transport infrastructure (roads, railways)	Incompatible	Compatible with conditions (see note 14)	Acceptable
Marina (includes boat moorings and servicing)	Incompatible	Incompatible	Compatible with conditions
Marine filling station (boat fuelling)	Incompatible	Incompatible	Compatible with conditions
Market (food; general produce; second-hand goods)	Incompatible	Incompatible	Acceptable (see note 1)
Medical centre	Incompatible	Incompatible	Acceptable (see note 1)
Motel	Incompatible	Incompatible	Acceptable (see note 1)
Motor vehicle, boat or caravan sales (sales yards)	Incompatible	Incompatible	Acceptable (see note 1)
Motor vehicle repair	Incompatible	Incompatible	Compatible with conditions
Motor vehicle wash	Incompatible	Incompatible	Compatible with conditions
National and regional parks and nature reserves	Acceptable	Acceptable	Acceptable
Night club	Incompatible	Incompatible	Acceptable (see note 1)
Office	Incompatible	Compatible with conditions	Acceptable (see note 1)
Park home park	Incompatible	Incompatible	Compatible with conditions (see note 1)
Place of worship	Incompatible	Incompatible	Acceptable (see note 1)
Plantation	Compatible with conditions (see note 11)	Compatible with conditions (see note 11)	Acceptable
Reception centre	Incompatible	Incompatible	Acceptable (see note 1)
Recreation – private (within non-designated recreation areas on Crown land)	Incompatible	Incompatible	Acceptable
Residential building			
- house	Compatible with conditions (see note 16)	Acceptable (see note 4)	Acceptable (see note 1)
- group dwellings (aged and dependent persons)	Incompatible	Incompatible	Acceptable (see note 1)
Restaurant	Incompatible	Incompatible	Acceptable (see note 1)
Restricted premises (adult interests)	Incompatible	Incompatible	Acceptable (see note 1)
Rural pursuit	See Agriculture, Animal establishment or husbandry		
Service station (includes aircraft, automotive repairs, boats, mechanical plant, service stations at transport and municipal works depots)	Incompatible	Incompatible	Compatible with conditions (refer to note 1)
Shop	Incompatible	Compatible with conditions (see note 2)	Acceptable (see note 1)
Showroom	Incompatible	Incompatible	Acceptable (see note 1)
Storage			
- used tyres (see note 22)	Incompatible	Incompatible	Incompatible

Model Scheme Text & interpreted type of land use	P1 areas	P2 areas	P3 areas
- chemical storage in under ground tanks	Incompatible	Incompatible	Compatible with conditions
- chemical storage in above ground tanks	Incompatible	Compatible with conditions	Compatible with conditions
Tavern	Incompatible	Incompatible	Acceptable (see note 1)
Telecommunications infrastructure	Compatible with conditions	Compatible with conditions	Compatible with conditions
Toilet blocks and change rooms	Compatible with conditions (see note 2)	Compatible with conditions	Acceptable
Trade display	Incompatible	Incompatible	Acceptable (see note 1)
Veterinary centre	Incompatible	Compatible with conditions (see note 2)	Compatible with conditions (see note 1)
Warehouse	Incompatible	Compatible with conditions (see note 2)	Compatible with conditions (see note 1)
Waste transfer station (includes recycling depots)	Incompatible	Incompatible	Compatible with conditions
Wastewater infrastructure			
- sewerage – gravity sewers	Incompatible	Incompatible	Acceptable
- sewerage – pressure mains	Incompatible	Compatible with conditions	Acceptable
- sewer pump stations	Incompatible	Compatible with conditions	Compatible with conditions
- treatment plants, wastewater disposal to land	Incompatible	Incompatible	Compatible with conditions
- wastewater injection into the ground (see note 25)	Incompatible	Incompatible	Incompatible
Water treatment plants (drinking)	See Industry		
Winery (includes wine tasting facilities)	Incompatible	Compatible with conditions (see notes 3 & 5)	Compatible with conditions (see note 3)

Table recommending compatibility of land subdivision within PDWSA: Note - This table reflects the recommended size of a subdivision based on the existing zoning and the priority classification area status of land. It should be noted that Town Planning Scheme provisions for specific zones and reserves will take precedent over the following recommended lot sizes.

Form of subdivision (specific to current zoning)	P1 areas	P2 areas	P3 areas
Rural subdivision			
- to a lot size of 4 hectares or greater	Incompatible	Acceptable	Acceptable
- to a lot size less than 4 hectares	Incompatible	Incompatible	Incompatible
Special rural subdivision			
- to a lot size of 2 hectares or greater	Incompatible	Compatible with conditions (see notes 7 & 8)	Compatible with conditions (see note 8)
- to a lot size between 1 and 2 hectares	Incompatible	Incompatible	Compatible with conditions (see notes 7 & 8)
- to a lot size less than 1 hectare	Incompatible	Incompatible	Compatible with conditions (see note 7)
Urban subdivision	Incompatible	Incompatible	Acceptable (see note 1)
Industrial subdivision	Incompatible	Incompatible	Acceptable (see note 1)

Explanatory notes related to land uses described the tables:

The following notes provide interpretive information based on the scale or type of development described in the preceding tables. They do not list all the conditions that could apply to any activity or development.

1. Must be connected to deep sewerage, except where exemptions apply under State Government Sewerage Policy. The Policy recognises that sewer connection may be impractical in some areas. Under these circumstances maximum wastewater loadings (based on people/ hectare) apply linked to the management Priority of the site.
2. The land use is normally incompatible, but may be conditionally approved where this facility is consistent with approved State and local government planning strategies or schemes.
3. The land use must incorporate best environmental management practices compatible with the management strategy for the designated priority area defined in the relevant source protection plan.
4. In Priority 2 areas: conditions may apply to density of dwellings (i.e. hectares per dwelling).
5. Size of the grape crush shall not exceed 500 tonnes per year.
6. May be approved if occupancy is of equivalent size to a single dwelling household (i.e. less than 10 people– defined by capacity of a septic tank based on-site wastewater treatment system).
7. An average, rather than minimum, lot size may be accepted if the proponent can demonstrate that the water quality objectives of the source protection area are met, and caveats/memorials are placed on titles of specified blocks stating that further subdivision shall not occur.
8. Lots should only be created where land capability assessment shows that effective on-site soakage of treated wastewater can be achieved. Conditions apply to siting of wastewater disposal systems in areas with poor land drainage and/ or a shallow depth to groundwater, animals are held or fertiliser is applied. Alternative wastewater treatment systems, where approved by the Department of Health, may be accepted with ongoing maintenance requirements.
9. Conditions are likely to be placed via a Department of Industry and Resources mineral tenement lease, and / or as a result of Minister for the Environment’s approval after an Environmental Impact Assessment.
10. Conditions apply to the storage of fuels and chemicals, the depth of excavation related to the water table and rehabilitation criteria. Underground fuel or chemical storage tanks are prohibited via DoE by-laws in Priority 1 and 2 areas within Underground Water Pollution Control Areas.
11. Conditions apply to regulate fertiliser and pesticide application.
12. Can be approved if animal stocking levels (animals per hectare, guided by the Department of Agriculture’s stocking rate guidelines) are consistent with the priority source protection area objectives.
13. This does not include stockyards occasionally used on farms or pastoral leases for animal husbandry.
14. Conditions may be imposed to cover design, construction of infrastructure and the types of goods.
15. May only be approved if *Home Occupation* relates to an existing residence.
16. Limited to one residential building per property.
17. Includes land or buildings dominantly used for the showing, competition or training of horses, and riding schools.
18. Includes any land, building or structure used for equine (e.g. horses, asses, mules and donkeys) housing, keeping and feeding and associated activities.
19. In accordance with *Community Services (Child Care) Regulations 1988: A child care service provided to a child in a private dwelling in a family of or domestic environment. No more than 5 children of pre-school age and no more than 7 children under 12 years old, including the children of the licensee or permit holder.*

APPENDIX 10

LAND ACCESS REVIEW PANEL – MATRIX OF INTERACTION

	CSG-LNG	Coal	Minerals
Large grazing properties	<ul style="list-style-type: none"> Impact significant, particularly during exploration and construction phase. Impacts relatively easy to manage due to large property size and extensive nature of activity. Impact will be more in areas close to houses or farm infrastructure such as dams etc. 	<ul style="list-style-type: none"> Exploration impacts generally low due to nature of coal exploration but increase as intensity of exploration increases. Impacts relatively easy to manage due to large property size and extensive nature of activity. Impact will be more in areas close to houses or farm infrastructure such as dams etc. 	<ul style="list-style-type: none"> Exploration impacts generally very low level due to nature of mineral exploration. Impacts relatively easy to manage due to large property size and extensive nature of activity. Impact will be more in areas close to houses or farm infrastructure such as dams etc.
Broadacre farming	<ul style="list-style-type: none"> Impact significant, particularly during exploration and construction phase. Impacts relatively easy to manage due to large property size, but will require greater consideration of underlying land use. Impact will be more in areas close to houses or farm infrastructure such as dams etc. Potential for impacts on cultivation need to be carefully managed. 	<ul style="list-style-type: none"> Exploration impacts generally low due to nature of coal exploration but may increase as intensity of exploration increases. Impacts relatively easy to manage due to large property size but will be more in areas close to houses, sheds or farm infrastructure such as dams etc. Potential for impacts on cultivation need to be carefully managed. 	<ul style="list-style-type: none"> Exploration impacts generally very low level due to nature of mineral exploration. Impacts relatively easy to manage due to large property size and extensive nature of activity. Impact will be more in areas close to houses or farm infrastructure such as dams etc. Potential for impacts on cultivation need to be carefully managed.
Small and/or mixed-use farming	<ul style="list-style-type: none"> Impact can be significant during exploration and construction phase. Risk and scale of impact is increased due to more intensive and specialised farming techniques. Potential for impacts on cultivation and specialised management practices (e.g. cell grazing, feedlots) need to be carefully managed. 	<ul style="list-style-type: none"> Exploration impacts generally low due to nature of coal exploration but may increase as intensity of exploration increases. Potential for impacts on cultivation and specialised management practices (e.g. cell grazing, feedlots) need to be carefully managed. 	<ul style="list-style-type: none"> Exploration impacts generally very low level due to nature of mineral exploration. Mineral exploration activity in mixed farming areas is minimal but does occur. Potential for impacts on cultivation and specialised management practices (e.g. cell grazing, feedlots) need to be carefully managed.
Intense cropping, irrigation and/or organic farming	<ul style="list-style-type: none"> Impact can be significant throughout the life of the resources activities. Risk and scale of impact is increased due to intensive and specialised farming techniques. Potential for impacts on cultivation practices (particularly irrigation) and organic certification higher due to nature of activity and sensitivity to impact. 	<ul style="list-style-type: none"> Impact can be significant throughout the life of the resource activities. Risk and scale of impact is increased due to intensive and specialised farming techniques (particularly irrigation) and organic certification higher due to nature of activity and sensitivity to impact. 	<ul style="list-style-type: none"> Exploration impacts generally very low level due to nature of mineral exploration. Risk of impact is increased due to more intensive and specialised farming techniques. Mineral exploration activity in intensively cropped areas is minimal but does occur.

APPENDIX 11

QUEENSLAND LAND ACCESS CODE

PART 1 – INTRODUCTION

1 Background

The Queensland Government is committed to balancing the interests of the agricultural and resource sectors to address issues related to land access for resource exploration and development. Good relationships between these groups, assisted by adequate consultation and negotiation, will improve transparency, equity and cooperation across the sectors involved and creates a more level playing field for all.

This Land Access Code has been developed by the Queensland Government in consultation with the resource and agricultural sectors through the Land Access Working Group.

2 Purpose and application

Section 24A of the *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act) provides for the making of the Land Access Code by regulation. Section 24A states that ‘a regulation may make a single code for all resource Acts (the **land access code**) that—

- (a) states best practice guidelines for communication between the holders of authorities and owners and occupiers of private land; and
- (b) imposes on the authorities mandatory conditions concerning the conduct of authorised activities on private land.’

‘All resources Acts’ means the *Geothermal Energy Act 2010* (GE Act), *Geothermal Exploration Act 2009*, *Greenhouse Gas Storage Act 2009* (GHG Act), *Mineral Resources Act 1989* (MRA), *Petroleum Act 1923* (PA1923) and the *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act).

In relation to (a) above, Part 2 of this document provides the best practice guidelines for communication between the holders of authorities and owners and occupiers of private land.

In relation to (b) above, Part 3 of this document imposes on the following authorities mandatory conditions concerning the conduct of authorised activities on private land¹:

- (a) geothermal tenures under the *Geothermal Energy Act 2010*;
- (b) GHG authorities under the *Greenhouse Gas Storage Act 2009*;
- (c) petroleum authorities under the *Petroleum and Gas (Production and Safety) Act 2004*;
- (d) 1923 Act petroleum tenures under the *Petroleum Act 1923*;
- (e) exploration permits and mineral development licences under the *Mineral Resources Act 1989*.

The definitions contained in Part 3, section 11 apply to the entire Land Access Code document.

Part 4 of this document provides further details of information sources that may assist parties dealing with land access issues.

¹ See the *Petroleum and Gas (Production and Safety) Regulation 2004*, schedule 1A, part 1, section 1.

PART 2 – GOOD RELATIONS

3 Introduction

Establishing good relations between parties requires the use of common sense, a practical approach and mutual courtesy between all those involved in dealings between holders and landholders.

The development of good relations between landholders and holders requires recognition of the rights and obligations of both parties. Any person who enters property owned or managed by another party to undertake authorised activities on behalf of a holder should demonstrate common sense and courtesy, consult regularly, and comply with statutory and contractual obligations.

Below are general principles that should be followed by both parties when undertaking discussions and negotiations about land access and compensation.

4 General principles

Holder	Landholder
<ul style="list-style-type: none"> • Liaise closely with the landholder in good faith • Advise the landholder of the holder’s intentions relating to authorised activities well in advance of them being undertaken • Advise the landholder of any significant changes to operations or timing • Minimise damage to improvements, vegetation and land • Respect the rights, privacy, property and activities of the landholder • Rectify, without undue delay, any damage caused by the authorised activities • Promptly pay compensation agreed with the landholder once the agreed milestones are reached • Abide by this Code before, during and after undertaking activities • Be responsible for all authorised activities and actions undertaken by employees and contractors of the resource authority • Regard as confidential information obtained about the landholder’s operations. 	<ul style="list-style-type: none"> • Liaise with the holder in good faith • Provide responses to requests or notices with minimum delay • Advise the holder of any significant changes to operations or management programs • Engage with the holder to identify issues such as values of property and operational considerations • Respect the rights and activities of holders and provide reasonable access • Promptly notify the holder of any damage to property caused by the holder • Engage in negotiations with the holder to determine appropriate conduct and compensation arrangements • Adhere to principles of the Code and good neighbourly relations • Be responsible for all landholder activities, requests and actions undertaken on the property by landholder’s employees and contractors • Regard as confidential information obtained about the holder’s operations.

5 Communication

To assist in the development of effective working relationships from the outset, the holder should make early contact with the landholder and arrange to visit and inspect the property well in advance of any planned commencement of authorised activities. The landholder should endeavour to actively engage with the holder and make time available to discuss relevant issues that require detailed discussions.

To facilitate efficient communication in the initial stages of the process, the holder and landholder should each appoint a responsible person with good interpersonal skills to negotiate the agreement and undertake all communications in relation to land access. The holder should ideally appoint a competent representative such as the field supervisor or site manager who has knowledge of the land and experience in successfully liaising with landholders.

The responsible person:

- is the contact for the holder and landholder respectively
- for the holder, is responsible for all communication on behalf of their respective employees and contractors
- is responsible for negotiating any required agreement and should be authorised to make agreements and arrangements on behalf of the holder or the landholder
- should be familiar with all aspects and requirements of their operations.

The responsible person for the holder should provide the landholder with:

- contact details for themselves and a senior executive (who is contactable at any reasonable time)
- the resource authority number
- a description of the work program, including the extent and type of operations to be conducted and the duration of the program
- a description of vehicles and equipment to be used
- a detailed outline of the activity and a map including
- the location of fieldwork
- proposed access routes and camp locations
- any other relevant spatial information
- an overview of the environmental management plan including remediation/ rehabilitation works.

The landholder should provide the holder with comprehensive information about their property, including:

- the location of special features or special management requirements of the property
- advice on the best or preferred access routes
- suitable campsite locations
- water supply and location
- the timing and nature of significant farm programs (e.g. cropping, lambing, mustering)
- any property information relevant to the resource-related activities (e.g. tracks, fences, gates, bores, dams etc)
- any biosecurity issues on-farm or potentially in the area.

Provision of this information will assist in ensuring that the pre-planning and agreement negotiations can be undertaken based on full knowledge of both the proposed work program and the activities associated with use of the private land.

6 Negotiating agreements

Agreements between the landholder and holders should clearly articulate what has been agreed to between the parties and comply with the relevant resource Acts. In the course of negotiations, the parties should endeavour to stay in regular contact and work together to reach a mutually acceptable and practical agreement.

7 Communication before and during the carrying out of activities

The responsible person for the holder should:

- ensure that contact is made with the landholder at least one week prior to the agreed commencement date for undertaking authorised activities
- accompany drilling and other contractors on site at the time of initial entry
- conduct an orientation, with input from the landholder if required, for all persons acting on behalf of the holder.

It is the responsibility of the holder to ensure authorised activities are conducted within the resource authority area according to best practice and the mandatory conditions of the Land Access Code.

The responsible person for the holder should ensure that all agents, contractors and field personnel:

- carry the required authorisation to be on the land
- are aware of and adhere to:
 - the holder's policies and procedures relevant to field activities
 - the holder's responsibilities under the Land Access Code, any agreement in place and any other relevant statutory requirements
- potential compliance and enforcement actions associated with non-compliance with the Land Access Code.

Where practicable, the responsible person for the holder should maintain contact with the responsible person for the landholder throughout the work program, particularly:

- before commencing a new operational phase of a work program
- to obtain feedback from the landholder about the carrying out of the work program and any unforeseen impacts that the program is having on the landholder.

8 After completion of activities

Upon completion of the work program, the responsible person for the holder should inform the landholder about:

- the potential use of incidental infrastructure following completion of any activities (e.g. drill pads, access tracks, borrow pits, casing etc)
- the likelihood of any subsequent activities occurring (e.g. seismic program, further drilling etc).

The responsible person for the holder should invite the landholder to inspect the work area when the project is finished so that any problems can be discussed. The *Environmental Protection Act 1994* provides for landholder sign-off for rehabilitation. The responsible person for the landholder is encouraged to participate in this process.

PART 3 – MANDATORY CONDITIONS FOR RESOURCES AUTHORITIES²

9 What this part is about

This part provides for the mandatory conditions for the following (each a **resource authority**) under the following Acts (each a **resource Act**)—

- (a) geothermal tenures under the *Geothermal Energy Act 2010*;
- (b) GHG authorities under the *Greenhouse Gas Storage Act 2009*;
- (c) petroleum authorities under the *Petroleum and Gas (Production and Safety) Act 2004*;
- (d) 1923 Act petroleum tenures under the *Petroleum Act 1923*;
- (e) exploration permits and mineral development licences under the *Mineral Resources Act 1989*.

10 Giving notice

A relevant person who is required to notify a landholder under this part must give the notice—

- (a) orally in person; or
- (b) if oral notice is impractical—by written notice.

Example of it being impractical to give oral notice—

The landholder has migrated to a place outside of Queensland.

11 Definitions

In this part—

access land, for a resource authority—

- (a) for a geothermal tenure—see the *Geothermal Energy Act 2010*, section 220(3); or
- (b) for a GHG authority—see the *Greenhouse Gas Storage Act 2009*, section 287(3); or
- (c) for a petroleum authority—see the *Petroleum and Gas (Production and Safety) Act 2004*, section 502(3); or
- (d) for any other resource authority—means land it is reasonably necessary to cross for access to land under the resource authority.

authorised activity, for a resource authority, means an activity that its holder is, under the authority of the relevant resource Act, entitled to carry out in relation to the resource authority.

holder means a person who, under a resource Act, holds a resource authority.

landholder means an owner or occupier of private or public land in the area of, or access land for, a resource authority.

relevant person means—

- (a) the holder of a resource authority; or
- (b) a person acting for a holder under a resource authority.

resource Act see section 9.

resource authority see section 9.

² See the *Petroleum and Gas (Production and Safety) Regulation 2004*, schedule 1A.

12 Induction training

- (1) A holder must ensure each person acting for the holder, under the holder's resource authority, receives information and training specific to the obligations of the holder and the person under each of the following for authorised activities that will be carried out by the person on a landholder's land—
 - (a) the resource Acts;
 - (b) the land access code;
 - (c) an agreement between the holder and the landholder.
- (2) A holder must give each person mentioned in subsection (1) a document to show the person has received the appropriate information and training.
- (3) A holder must, if asked by the landholder, give the landholder a copy of the document.

13 Access points, roads and tracks

- (1) A relevant person must, if practicable, use an existing access point, road or track to enter a landholder's land.
- (2) If it is not practicable to comply with subsection (1), any new access points, roads or tracks, made by the relevant person, must be located at a place and in a way that minimises the impact of the access point, road or track on the landholder's business or land use activities.
- (3) A relevant person must, for the period the access points, roads or tracks are used by the person, ensure the access points, roads or tracks are kept in good repair.
- (4) For subsection (3), the relevant person must have regard to the condition of the access point, road or track when the person started using them.
- (5) A relevant person must operate vehicles on a landholder's land at speeds that—
 - (a) are appropriate for the landholder's land; and
 - (b) minimise noise, dust and disturbance to the land.
- (6) A relevant person may operate a vehicle in wet conditions on a landholder's land only in a way that minimises damage to access points, roads and tracks on the land.
- (7) If a relevant person has caused damage to access points, roads or tracks on a landholder's land, the relevant person must, as soon as practicable—
 - (a) notify the landholder of the damage; and
 - (b) repair the damage.

14 Livestock and property

- (1) A relevant person must use a landholder's land in a way that minimises disturbance to people, livestock and property.
- (2) If, in carrying out authorised activities, a relevant person becomes aware of any potential adverse impact, caused by the activities, on a landholder's livestock or property, the relevant person must immediately notify the landholder of the potential impact.
- (3) If a relevant person injures or kills a landholder's livestock, the relevant person must immediately notify the landholder of the injury or death of the livestock.
- (4) If a relevant person damages a landholder's property, the relevant person must—
 - (a) immediately notify the landholder of the damage; and
 - (b) repair the damage as soon as practicable.

15 Obligation to prevent spread of declared pests

- (1) A relevant person must take all reasonable steps to ensure that, in carrying out authorised activities, the person does not spread the reproductive material of a declared pest.
- (2) A relevant person must take all reasonable steps to ensure that, in entering or leaving land in the area of a resource authority, the person does not spread the reproductive material of a declared pest.

Note — For further information on preventing the spread of declared pests see the document called ‘Petroleum Industry–Pest Spread Minimisation Advisory Guide’ published by the department in which the *Land Protection (Pest and Stock Route Management) Act 2002* is administered.

- (3) Subsections (1) and (2) do not apply to the release of a declared pest authorised under the *Land Protection (Pest and Stock Route Management) Act 2002*.
- (4) A holder must ensure each person acting for the holder under a resource Act washes down vehicles and machinery before entering a landholder’s land in the area of the resource authority, if the risk of spreading a declared pest is likely to be reduced by the washing down.
- (5) The holder must keep a record (the **wash-down record**) of all wash-downs under subsection (4) carried out during the period in which the holder is allowed access to the landholder’s land.
- (6) If asked by the landholder, the holder must give a copy of the wash-down record to the landholder.
- (7) In this section—

declared pest means—

- (a) a declared pest under the *Land Protection (Pest and Stock Route Management) Act 2002*, schedule 3; or
- (b) an animal or plant declared under a local law to be a pest because the animal or plant is causing, or has the potential to cause, an adverse environmental, economic or social impact in all or part of the local government area.

reproductive material, of a declared pest, see the *Land Protection (Pest and Stock Route Management) Act 2002*, schedule 3.

wash-down means the removal of reproductive material from a vehicle or machine using an appropriate cleaning process.

16 Camps

- (1) If a holder intends to set up a camp on a landholder’s land, the holder and the landholder must, before the camp is set up, agree on the location and a plan for managing the camp.
- (2) However, if the holder and landholder cannot agree on a location and plan for managing the camp, the holder must ensure the location of the camp is in a place that will minimise any impact on the landholder’s business or land use activities.

17 Items brought onto land

- (1) A relevant person carrying out authorised activities must collect rubbish or waste produced in carrying out the authorised activities and deposit the rubbish and waste in a suitable local waste facility.
- (2) A relevant person must not bring firearms, domestic animals or alcohol onto a landholder’s land without the landholder’s consent.
- (3) In this section—

local waste facility means a waste facility owned, operated or otherwise controlled by a local government.

18 Gates, grids and fences

- (1) A relevant person must, after using a gate, return the gate to its original position unless advised otherwise by the landholder.
- (2) If a relevant person damages a grid on a landholder's land the person must—
 - (a) immediately notify the landholder of the damage; and
 - (b) replace or repair the grid as soon as practicable.
- (3) A relevant person must—
 - (a) obtain the landholder's consent before erecting a gate on the landholder's land; and
 - (b) ensure any gate erected by the person is stock-proof.
- (4) A relevant person must not cut a fence on the landholder's land without the landholder's consent.
- (5) If the landholder allows a fence to be cut by a relevant person to carry out an authorised activity, the person must, immediately after carrying out the activity—
 - (a) repair the fence; or
 - (b) erect a stock-proof gate, as required by the landholder, where the fence was cut.

APPENDIX 12

COMPILATION OF PUBLISHED STATISTICS ON WELL BARRIER AND WELL INTEGRITY FAILURE: R DAVIES ET AL, 2014

Compilation of published statistics on well barrier and well integrity failure, including information on well age, number of wells included in study, well location, and terminology used to describe nature of well barrier or integrity failures.

Country	Location	No. Wells studied	% Wells with barrier failure or well integrity failure	Additional information	Published source
USA	ONSHORE Operational wells in the Santa Fe Springs Oilfield (discovered ~ 1921), California, USA	>50	75	Well Integrity failures. Leakage based on the 'observation of gas bubbles seeping to the surface along well casing'.	Chillingar and Endres (2005)
USA	ONSHORE Ann Mag Field, South Texas, USA (wells drilled 1998–2011)	18	61	Wells drilled 1998–2011. Well barrier failures mainly in shale zones.	Yuan et al. (2013)
USA	OFFSHORE Gulf of Mexico (wells drilled ~ 1973–2003)	15,500	43	Wells drilled ~ 1973–2003. Barrier failure, 26.2% in surface casing.	Brufato et al. (2003)
Offshore Norway	OFFSHORE Norway, 8 Companies, Abandoned Wells (wells drilled 1970–2011)	193	38	Wells drilled 1970–2011. Well integrity and barrier failure. 2 wells with likely leak to surface.	Vignes (2011)
China	ONSHORE Kerxi Reservoir, China (dates unknown)	160	31.3	Well barrier failure	Peng et al. (2007)
China	ONSHORE Gudao Reservoir, China (wells drilled 1978–1999)	3461	30.4	Wells drilled 1978–1999. Barrier failure in oil-bearing layer.	Peng et al. (2007)
Offshore Norway	OFFSHORE Norway, 8 Fields (dates unknown)	217	25	Wells monitored 1998–2007. Well integrity and barrier failure. 32% leaks occurred at well head.	Randhol and Carlsen (2007)
Canada	ONSHORE Saskatchewan, Canada (dates unknown)	435	22	Wells monitored 1987–1993. Well integrity failure: SCVF and GM	Erno and Schmitz (1996)
Offshore Norway	OFFSHORE Internal Audit, Location Unknown (dates unknown)	711	20	Barrier failure	Nilsen (2007)
Offshore Norway	OFFSHORE Norway, 12 Offshore Facilities (wells drilled 1977–2006)	406	18	Wells drilled 1977–2006. Well integrity and barrier failure. 1% had well head failure.	Vignes and Aadnøy (2010)
China	ONSHORE Daqing Field, China (wells drilled ~ 1980–1999)	6860	16.3	Wells drilled ~ 1980–1999. Barrier failure	Zhongxiao et al. (2000)
Bahrain	ONSHORE Bahrain (wells drilled 1932–2004)	750	13.1	Wells drilled 1932–2004. Failure of surface casing with some leaks to surface	Sivakumar and Janahi (2004)
Netherlands	ONSHORE Netherlands (dates unknown)	31	13	Barrier failure	Vignes (2011)
UK	OFFSHORE UK Continental Shelf (dates unknown)	6137	10	Well integrity and barrier failure.	Burton (2005)
USA	ONSHORE Marcellus Shale, Pennsylvania, USA (wells drilled 1958–2013)	8030	6.26	Well reports 2005–2013. Well integrity and barrier failure. 1.27% leak to surface.	This study
China	ONSHORE Gunan Reservoir, China (dates unknown)	132	6.1	Barrier failure	Peng et al. (2007)
USA	ONSHORE Nationwide Gas Storage Facilities (< 1965–1988)	6953	6.1	Wells drilled < 1965–1988. Well integrity and barrier failure.	Marlow, 1989
China	ONSHORE Hetan Reservoir, China (dates unknown)	128	5.5	Barrier failure	Peng et al. (2007)
USA	ONSHORE Marcellus Shale, Pennsylvania, USA (wells drilled 2010–2012)	4602	4.8	Wells drilled 2010–2012. Well barrier and integrity failure.	Ingraffea (2012)
Canada	ONSHORE Alberta, Canada (wells drilled 1910–2004)	316,439	4.6	Wells drilled 1910–2004. Monitored 1970–2004. Well integrity failure: SCVF and GM	Watson and Bachu (2009)
Indonesia	ON/OFFSHORE Malacca Strait (wells drilled ~ 1980–2004)	164	4.3	Wells drilled ~ 1980–2010. Both well integrity and barrier failures. Further 41.4% of wells identified as high risk of failure.	Galosa and Sadarta (2010)
USA	ONSHORE Pennsylvania, USA (wells drilled 2008–2013)	6466	3.4	Wells drilled 2005–2012. Well integrity and barrier issues. Leak to surface in 0.24% wells.	Vidic et al. (2013)
China	ONSHORE Kenli Reservoir, China (dates unknown)	173	2.9	Barrier failure	Peng et al. (2007)
USA	ONSHORE Marcellus Shale, Pennsylvania, USA (wells drilled 2008–2011)	3533	2.58	Wells drilled 2008–2011. Well integrity and barrier failure	Considine et al. (2013)
USA	ONSHORE Nationwide CCS/Natural Gas Storage Facilities (dates unknown)	470	1.9	Well integrity failure. Described as significant gas loss.	IPCC (2005)

APPENDIX 13

AVERAGE EXPOSURE TO WATER STRESS ACROSS SHALE PLAYS: WORLD RESOURCES INSTITUTE

A. TWENTY COUNTRIES WITH THE LARGEST TECHNICALLY RECOVERABLE SHALE GAS RESOURCES

RANK*	COUNTRY	AVERAGE EXPOSURE TO WATER STRESS OVER SHALE PLAY AREA
1	China	High
2	Argentina	Low to Medium
3	Algeria	Arid & Low Water Use
4	Canada	Low to Medium
5	United States	Medium to High
6	Mexico	High
7	Australia	Low
8	South Africa	High
9	Russian Federation	Low
10	Brazil	Low
11	Venezuela	Low
12	Poland	Low to Medium
13	France	Low to Medium
14	Ukraine	Low to Medium
15	Libya	Arid & Low Water Use
16	Pakistan	Extremely High
17	Egypt, Arab Rep.	Arid & Low Water Use
18	India	High
19	Paraguay	Medium to High
20	Colombia	Low

B. TWENTY COUNTRIES WITH THE LARGEST TECHNICALLY RECOVERABLE TIGHT OIL RESOURCES

RANK*	COUNTRY	AVERAGE EXPOSURE TO WATER STRESS OVER SHALE PLAY AREA
1	Russian Federation	Low
2	United States	Medium to High
3	China	High
4	Argentina	Low to Medium
5	Libya	Arid & Low Water Use
6	Australia	Low
7	Venezuela, RB	Low
8	Mexico	High
9	Pakistan	Extremely High
10	Canada	Low to Medium
11	Indonesia	Low
12	Colombia	Low
13	Algeria	Arid & Low Water Use
14	Brazil	Low
15	Turkey	Medium to High
16	Egypt, Arab Rep.	Arid & Low Water Use
17	India	High
18	Paraguay	Medium to High
19	Mongolia	Extremely High
20	Poland	Low to Medium

APPENDIX 14

PUBLIC DRINKING WATER SOURCE AREAS

