REGULATION OF SHALE, COAL SEAM AND TIGHT GAS ACTIVITIES IN WESTERN AUSTRALIA

FINAL

An analysis of the capacity of the Petroleum and Geothermal Energy Act 1967 (WA) to regulate onshore gas activities in Western Australia

Includes corrections to structure actioned by Dr Tina Hunter on 25th October 2011.
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EXECUTIVE SUMMARY

Recent activities in the USA and eastern Australian States (particularly Queensland and NSW) have focused attention on the extraction of shale gas and coal seam gas (together known as unconventional gas resources). Public perception of the extraction of these sources of gas, particularly the process of fracing, has been influenced by recent media attention. In particular, the movie *Gasland* and an episode of *Four Corners* that aired on 21 February 2011 has focused the public's attention on shale gas extraction in WA.

This report examines the existing regulatory framework for the extraction of onshore Shale Gas Resources (SGR) in Western Australia. It has been commissioned by the WA Department of Mines and Petroleum (WADMP) in response to community concerns expressed regarding the process of fracing for the production of shale gas. It assesses the capacity of the current legislation, the *Petroleum and Geothermal Energy Resources Act 1967* (WA) (PAGERA), to regulate shale gas exploration and production activities. It also assesses other issues that the WADMP should consider when managing shale gas extraction.

The following assessment and conclusions represent an independent, unbiased assessment of the capacity of the WADMP to regulate present and future shale gas activities in this WA.

The WADMP needs to focus on differentiating the unique nature of shale gas activities in this state. Otherwise, it risks comparisons to shale gas extraction in the USA or Coal Seam Gas extraction in NSW and Queensland. Furthermore it needs to address water usage issues associated with shale gas extraction, since water extraction is a major source of distress and misunderstanding for the community when shale gas is extracted.

Recommendation 1: The Western Australian Department of Mines and Petroleum should develop a policy/strategy for the management of produced water from fracing processes. This strategy should be based on best practice, taking into domestic and international experiences.

Management of produced water resources is also an important consideration. It is recommended that WADMP undertake the following:

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.

Recommendation 12: The Department of Mines and Petroleum ensure the inclusion of management of produced water from abandoned wells in any proposed Environment Regulations and Resource Management Regulations.

The use of chemicals in the fracing process is another cause of community distress. Experience in other jurisdictions indicates that full disclosure of chemicals allowed in the fracing process be included on the Department of Mines and Petroleum website.

Recommendation 3: The Western Australian Department of Mines and Petroleum should provide full, transparent disclosure of all chemicals used in WA fracing operations. This disclosure should be made available on the WADMP web site.

Experience in NSW and Queensland demonstrates that conflict in land use and land access is a central issue in coal seam gas extraction, especially due to conflict between gas production and agriculture use. Given the vast size of Western Australia, it is essential that the WADMP address land use and land access issues, identifying different land uses and stakeholders, and the likely conflicts between these groups.

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

1. *Legislative provisions contained within the PAGERA (objects clause)*
2. *A pre-emptive land use management strategy developed in consultation with relevant stakeholders and communities.*

In his response to a media inquiry form the *Busselton Times* on 31 May 2011, The Hon. Norman Moore, Minister for Mines and Petroleum, stated that WA has stringent regulatory processes in place to ensure that industry development of shale gas resources will be done so in a responsible and sustainable way. This assessment of the regulatory processes as sustainable and responsible is accurate. However there are concerns regarding the integrity of the legislative framework that underpins the processes. In short the legislative regime for resource and environment lacks legal enforceability, attributable to the absence of resource management regulations and environment regulations under the PAGERA. Whilst there is a legislative gap, the rigorous application of process and the skill and dedication of staff provides assurance that the current processes are adequate to protect the environment. The introduction of environmental regulations and resource management regulations are essential to provide legal enforceability of exciting processes, and to provide legal certainty and enforceability on new areas of regulation in the upstream petroleum chain.

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.*

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.

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 processes to ensure that there are complementarities and the current safety regulations apply across the petroleum chain for onshore shale gas activities..

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.

Recommendation 10: The WADMP undertake to write resource regulations to regulate onshore petroleum activities, including the recovery of coal seam and shale gas.

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.

Recommendation 14: The WADMP develop a standard Petroleum and Land Access process overview for the abandonment of a field.

Staff at the Department of Mines and Petroleum are integral to the successful management of onshore petroleum resources, particularly well design. However, as staff age, and the volume of wells requiring approval increases, there is an imperative to capture the knowledge and experience of existing staff, and to plan for staff retirement, illness or death.

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.

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.

Queensland has established the LNG Enforcement Unit (LNGEU) to regulate, process and manage the over 40,000 wells that are to be drilled in the next five years. At present such a unit is not required in WA. However, should Departmental relationships, regulatory processes or standards alter, or the number of wells to be drilled dramatically increase it may be necessary for the WADMP to reconsider the establishment of a LNGEU similar to that established in Queensland.

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.

1. INTRODUCTION

The potential of shale and coal formations as sources of gas has been known for several decades, but have remained underdeveloped due to the difficulty in recovering gas from these formations. However, as security of energy supply emerges as a major economic and political threat, there is an increasing need to develop more difficult gas resources from formations that have not traditionally been considered as gas-yielding. The gas recovered from shale and coal formations is generally referred to as unconventional gas, whilst gas recovered from sandstone and carbonate formations is generally referred to as conventional gas. The gas recovered from both types of gas formations is the same: naturally occurring hydrocarbon gas, primarily comprising methane, but also containing ethane, propane and butane in smaller proportions.

Shale gas typically occurs in shale formations with low porosity and permeability, retarding the capacity of the gas to flow freely from the formation. As such, there is often a need for well stimulation techniques to be undertaken to recover the gas. As new technologies and materials are developed to extract the substantial shale gas resources, shale gas is becoming an increasingly important source of energy. This has been particularly evident in the USA, where in the last 10 years 20-26 trillion cubic feet (tcf) of shale gas has been produced annually.[1] In comparison, gas production from the Gulf of Mexico has declined, with only 2-3tcf produced annually since 2005.[2] This represents a 12 fold increase in shale gas production, now representing 25% of total US gas production[3] and increasing annually. As a result of increased supply, prices for domestic gas in the United States have declined significantly from $8.00/Mcf IN 2008 to $3.75/Mcf in 2010.

Generally these shale gases are released from the geological formations using well stimulation processes, particularly hydraulic fracturing (fraccing). Although the process of fraccing has been utilised for over 40 years as a method to develop gas resources, its use has dramatically increased in the last 10 years, particularly in the USA. In the last few years fraccing has also become common in liberating coal seam gas (CSG) in Queensland and NSW.

The use of fraccing, especially in the USA, has raised considerable community concern. The potential damage the fraccing process may cause aquifers, and the chemicals used in the process has been the subject of much controversy. This controversy was heightened with the release of the US movie *Gasland*, which highlights the fraccing process, casting aspersions on the process and the chemicals used, and episode of *Four Corners* aired on 21 February 2011. The widespread publicity from these films has raised concerns within the Western Australian community regarding the safety of the fraccing process for human health and the environment. Added to this concern are a number of incidents regarding coal seam gas (or coal bed methane) in NSW and Queensland, and the capacity of those states to regulate coal seam gas extraction. Together, these incidents have heightened community concern over the capacity of the Western Australian government to adequately regulate shale gas activities in WA.

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[1] Congressional Research Services, *Unconventional Gas Shales: Development, Technology and Policy Issues* (2009), 3.

[2] Ibid.

[3] Richard Newell, *Shale Gas and the Outlook for US Natural Gas Markets and Global gas Resources* (2011) Presentation at the Organisation for Economic Cooperation and Development, Paris, 21 June, 2011, 11.

This report will address these concerns by outlining and analysing the current regulatory processes and framework of the Department of Mines and Petroleum for the extraction of coal seam gas.

2. SCOPE OF THE REPORT

This report seeks to examine the existing regulatory framework for the extraction of onshore Shale Gas Resources (SGR) in Western Australia, in response to the concerns expressed by the community regarding the process of fraccing for the production of shale gas. It will assess the capacity of the current legislation, namely the *Petroleum and Geothermal Energy Resources Act 1967* (WA) (PAGERA), to regulate shale gas exploration and production activities. To address the community concerns, this report seeks to:

- Outline and assess the current legal framework regulating onshore shale gas activities in Western Australia;
- Assess the rigour the processes relevant for onshore shale gas exploration, appraisal and production;
- Assess the role of the Department of Mines and Petroleum in the management of shale gas activities in Western Australia;
- Consider the role of Shale Gas resources in addressing security of energy supply in Western Australia; and
- Provide recommendations on how the regulatory capacity of the PAGERA could be improved to ensure comprehensive regulation of shale gas activities across the upstream petroleum chain.

This report will focus upon the regulation of shale gas activities through the upstream petroleum chain, which encompasses

- Exploration;
- Appraisal and development;
- Production; and
- Field abandonment.

It will not consider the management of revenue and royalties, or the management of downstream petroleum activities such as transport, sale and distribution of gas resources. The assessment of shale gas resources will apply equally to coal seam gas and tight gas resources (together known as unconventional gas resources).

Information contained in this report has been obtained from the following sources:

- Independent research , particularly government sources and academic papers
- Interviews with relevant Division and Branch Managers; as well as other staff members where appropriate. A list of members of staff interviewed is contained in appendix 1; and
- Western Australia's Department of Mines and Petroleum (WADMP) process documents that are available on the WADMP intranet. Where reference has been made to internal WADMP processes, the intranet address of the relevant process is provided, and a copy of the process is provided as an appendix.

3. IMPORTANCE OF SHALE GAS IN GLOBAL ENERGY SECURITY

Shale gas has become an important global source of gas. The combination of the development of horizontal drilling and fraccing has greatly increased the likelihood for profitable extraction of shale gas from shale formations. Successful large-scale gas production was undertaken on the Burnett Shale formation in Texas during the 1980s and 1990s.[4] With demonstrated profitability of shale gas extraction, natural gas producers sought to produce gas from other formations, notably the Fayetteville and Haynesville Formations, as well as the Marcellus Shales under the Appalachian Mountains.

The development of these shale gas plays became an energy 'game changer' for the USA.[5] Long dependent upon the Middle East for hydrocarbon energy as domestic sources dwindle, the capacity to recover shale gas to meet US energy has become strategically and politically important. Today US shale gas resources are estimated at 862tcf.[6] US total gas reserves are estimated at be 2543 tcf. As such, SGR constitute 34% of the current US of the US natural gas resource base. Shale gas is projected to comprise 46% of US natural gas production by 2035. This has clear implications for US long term energy security geopolitical strategy. In its assessment of the role of shale gas in national security, the *James A Baker Institute for Public Policy* notes that rising shale gas production has already had profound repercussions in domestic and international markets, impacting on geopolitics, as well as domestic and international gas prices.[7] This is likely to continue.

An assessment of 14 gas regions (32 countries) outside the USA by the US Energy Information Administration (EIA) concluded that current recoverable shale gas in these 14 regions (of which one was Australia) is 4760 tcf.[8] Combined with the US recoverable estimates, the estimated recoverable reserves of shale gas is 5622 tcf. Given the world's recoverable gas resources in conventional reservoirs of 6609 tcf, the capacity to recover shale gas almost doubles the amount of recoverable gases. Clearly the recovery of shale gas is essential to meet growing needs for energy security in many nations.

Technological advancements in LNG processing and transport in the last 10 years has strongly contributed to the strengthening of the role of gas in the global energy market. Gas transportation from source to market is no longer a victim of 'tyranny of distance', dependent upon the construction of expensive pipelines. Instead, LNG transportation has enabled greater globalisation of gas markets, mirroring the experience of oil markets in the 1970s.[9]

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[4] US Energy Information Administration, *World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States* (EIA, 2011), 1.

[5] Ibid.

[6] Ibid.

[7] Kenneth B Medlock III, Amy Myers Laffe and Peter R Hartley, *Shale Gas and U.S National Security* (James A Baker III Institute for Public Policy, 2011), 9-10.

[8] Ibid, 2-3.

[9] Paul Stevens, *The 'Shale Gas Revolution': Hype and Reality* (Chatham House, 2010), 1.

As such it is likely that gas, particularly in the form of LNG, will contribute significantly in the future to the global gas market.

4. SHALE GAS EXTRACTION AND THE USE OF FRACCING

Shale gas is differentiated from conventional gas sources by the rock formations it is held in, and the technique required when extracting the gas. Whereas gas from sandstone and carbonate fields flows freely, the gas contained in shale formations requires well stimulation to liberate the gas and enable recovery. Fraccing increases the rate at which fluids can be produced from a reservoir, providing access to resources that would otherwise be inaccessible or commercially unviable.

What is Fraccing?

One of the primary techniques use for the stimulation shale wells to aid the recovery of this otherwise unrecoverable source of energy is hydraulic fracturing, commonly known as fraccing (or fracking). This technique involves isolating sections of a well in the shale formation, and the pumping of fluids and a proppant (generally grains of sand or other material used to hold the cracks open) down the wellbore through perforations in the casing and out into the shale. The pumped fluid is usually pressurised to over 8000 psi, generating sufficient pressure to fracture the shale formations as much as 1000 feet (300 metres). Fracturing fluids are used in the fraccing process in two ways: to assist in opening up the fracture and to transport the proppant along the length of the fracture.

Identified Risks Associated with Fraccing

Although fraccing has been a technique employed for the recovery of gas for over 60 years, its recent use to recover shale gas deposits has increasingly been scrutinised. Recent criticism of fraccing has highlighted numerous issues.

Use/depletion of aquifer

Fraccing is a water intensive operation, since it requires millions of litres of water in each fraccing. The water has two uses – to assist in fraccing and to transport the chemicals and proppants necessary to open the formation pores to enable the gas to escape. Estimates from US fraccing in the Marcellus formation indicate that water use of up to 5 million gallons per well would not be unexpected. In the Burnett formation, water use per well varies from 1.2-3.5 million gallons.[10]

Such high use of water requires adequate water resource policies to manage the use of water. It needs to be balanced with water use for other needs, especially agriculture and drinking water. Part of this management will include educating the public of the source of fraccing water, and assurance to the community of the continuity of drinking water supplies. In NSW and Queensland, there have been concerns that CSG activities are leading to marked

[10] Congressional Research Services, *Unconventional Gas Shales: Development, Technology and Policy Issues* (2009).

depletion of aquifers in prime agricultural regions, especially in the Gunnedah and Bowen/Surat basins.

The management of water resources in WA is undertaken by the Department of Water WADoW), who regulates access to water under the *Rights in Water and Irrigation Act 1914* (WA). An analysis of the allocation of water rights is outside the scope of this report, since water use is not regulated by WADMP. However, for completeness, WADoW should assess its regulatory capacity to respond to increased access to water resources in the future.

Disposal of 'produced' water

If millions of gallons of water are pumped into a well, it is logical that this water is returned to the surface as used or 'produced' water.

There has been much controversy surrounding produced water, particularly in the extraction of CSG in NSW and Queensland. Produced water from CSG differs markedly from water produced from fraccing in SGR. Water from CSG is generally briny, as a consequence of the salts in the coal formations. In addition, when fraccing occurs in CSG formations, it is used to assist in dewatering the coal seams. This contributes markedly to the produced water from CSG activities.[11]

Fraccing produces large volumes of water that contain salts and chemicals. Any undertaking of fraccing must necessarily include an adequate management plan for produced water. To date most management plans have included the use of evaporation ponds and containment pits (lined or unlined). Unusually high or unexpected rainfall, poor pond/pit design and/or construction have contributed to incidents involving such ponds. In some jurisdictions, including eastern Australia, there is a shift away from the use of such ponds for the treatment of produced water, with the use of evaporation ponds for CSG extraction banned in NSW.

Necessarily, any jurisdiction that undertakes fraccing will need to develop a strategy for the management of wastewater. When deciding on a management strategy for produced water, a regulator needs to consider the physical geology, hydrology, climate and rainfall of the jurisdiction. In a State the size of Western Australia, there may be a need for regional management plan, since there is a diverse range of climates in Western Australia, from the tropical north to the temperate south.

Recommendation 1: The Western Australian Department of Mines and Petroleum should develop a policy/strategy for the management of produced water from fraccing processes. This strategy should be based on best practice, taking into domestic and international experiences.

Contamination of water resources

One of the greatest concerns of fraccing is the contamination of water resources. This contamination originates from two main sources.

The first contamination source is surface water, and is linked to the management of produced water. If the produced water is not sufficiently contained, there is a possibility that

[11] Queensland Department of Environment and Resource Management, *Coal Seam Gas Water Management Policy* (2010), 1.

runoff from the pond in storm events or higher than normal rainfall periods may result in overflow of evaporation ponds. This water then contaminates other water sources through runoff. Adequate climatic and hydrological studies are required to assess the risk of contamination form surface water runoff.

The second source of water contamination is groundwater. Where unlined evaporation ponds are used, there is risk that contaminants may enter the groundwater system, thus contaminating the ground water resources. NSW has addressed this issue through the banning of evaporation ponds. Queensland has addressed the issue by requiring CSG operators to manage produced water as part of the Environmental Management plan (EMP). The Queensland approach has proved contentious, since the EMP is not seen as an adequate tool to manage produced water.

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.

Fracturing of surrounding formations affecting aquifers

Perhaps the greatest controversy surrounding fraccing in shale gas extraction is the danger of penetrating surrounding aquifers, thereby contaminating the aquifers. This has been demonstrated in the fraccing of Marcellus Shale formations in eastern USA. Some of these formations lie close to the drinking water aquifers for New York State. Several fraccing incidents have resulted in aquifer penetration, with contamination of local aquifers occurring.

The primary cause of aquifer penetration is poor well deign, resulting in aquifer contamination through well failure. This is particularly prevalent in areas such as the Marcellus Shale Formation where aquifers are close to the shale formation, and the shale formations are narrow. Aquifer penetration in the Perth and Canning Basins in Western Australia is unlikely since the shale formations are at great depth (over 2000m) and well away from aquifers, as well as generally being thick (generally over 100m), as illustrated in figure 1 below.

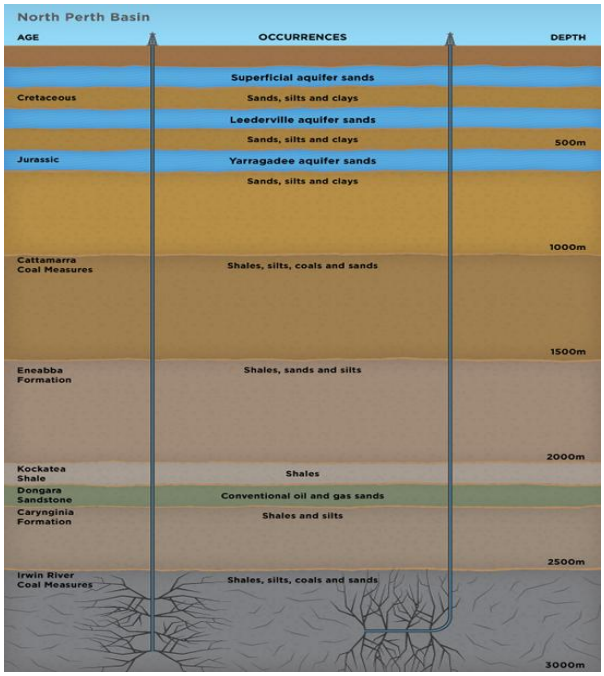


Figure 1: Typical stratigraphy of Perth Basin, demonstrating location and thickness of Shale Gas formations, and proximity to aquifers. Source: WADMP

Geomechanics research into fraccing has demonstrated no contamination of drinking water aquifers from thermogenic gas as a result of fracturing outside of the target formations. Instead aquifer contamination has been confined to poor well design and cementing rather than overstimulation of a well leading to fracturing beyond the target formation into drinking water aquifers.[12]

Chemicals used in Fraccing

The use of chemicals in the fraccing process is necessary for the opening and 'propping' of the shale formation to extract the gas. However the chemicals that are used have been the subject of much controversy. Such controversy has particularly surrounded the use of the chemicals Benzene, Toluene, Ethylbenzene and Xylenes, commonly known as BTEX's. These chemicals are mainly found in petroleum products, and have been implicated in health issues such as cancer and nervous system disorders.[13] There has been a major call to ban BTEX's both in Australia and internationally. NSW announced a permanent ban on BTEX compounds on 21 July 2011, citing 'community concerns, particularly in major agricultural areas in the Gunnedah Basin.

Given the controversy over fraccing chemicals, some companies involved in fraccing have commenced publishing the chemicals that are used in shale gas operations. Such transparency is appreciated by the public. Halliburton is one such company, disclosing all fluids used in the fraccing process.[14] An example of such disclosure is seen below.

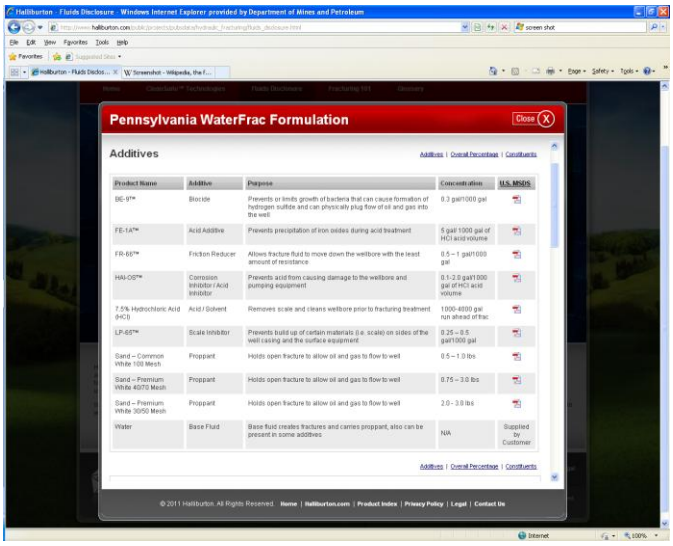


Figure 2: List of Chemicals published by Halliburton, including links to MSDS information for each chemical. Source: http://www.halliburton.com/public/projects/pubsdata/hydraulic_fracturing/fluids_disclosure.html

[12] Stephen Osborn, Avner Vengosh, Nathaniel Warner and Robert Jackson, ' Methane Contamination of Drinking Water and Accompanying Gas-well Drilling and Hydraulic Fracturing' (2011) *Proceedings of the National Academy of Sciences* 14 April 2011 www.pnas.org/cgi/doi/10.1073/pnas.1100682018

[13] Griffith University, *A Short Primer on BTEX in the environment and in hydraulic fracturing fluids* (2010), http://www.derm.qld.gov.au/environmental_management/coal-seam-gas/pdf/btex-report.pdf.

[14] This disclosure can be seen at http://www.halliburton.com/public/projects/pubsdata/hydraulic_fracturing/fluids_disclosure.html

Recommendation 3: The Western Australian Department of Mines and Petroleum should provide full, transparent disclosure of all chemicals used in WA fraccing operations. This disclosure should be made available on the WADMP web site.

5. SHALE GAS RESOURCES IN WESTERN AUSTRALIA

Major shale gas potential exists in four main onshore Australian geological basins. The cooper Basin, spanning South Australia and Queensland, is a proved basin. Other prospective basins are the Perth Basin in southwest Western Australia and the Canning Basin in northeast Western Australia. Small shale gas reserves are also present in the Officer Basin. A potential shale gas basin is the Maryborough Basin in Queensland. These Basins are illustrated in Figure 3 below.

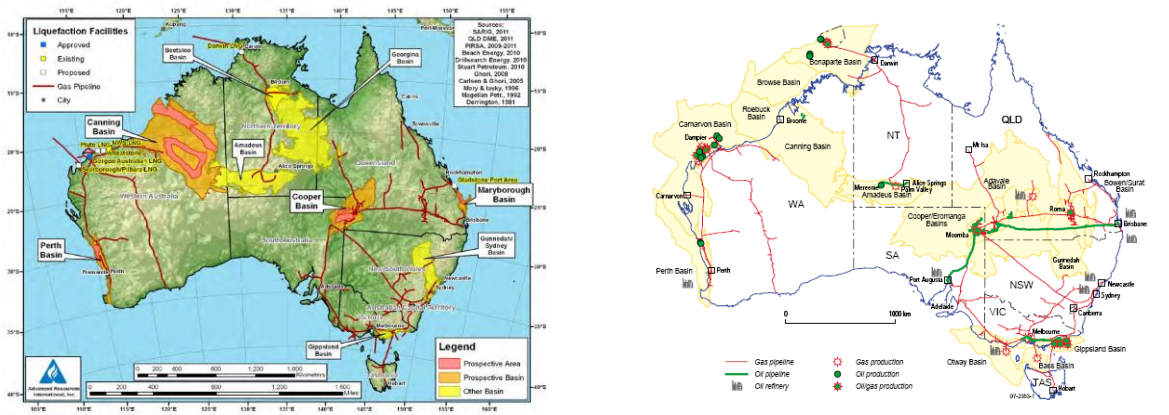


Figure 3: Major Shale Gas Basins in Australia. Source: US Energy Information Administration, World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States (EIA, 2011), XIV-2; Major Hydrocarbon Basins and gas pipelines in Australia. Source: Geoscience Australia.

Gas resources in Western Australia are divided between the offshore Bonaparte, Browse Perth and Carnarvon Basins and the onshore Canning and Perth Basins. Naturally occurring hydrocarbons dominate the offshore basins, while shale gas resources (SGR) dominate the onshore basins. As illustrated in figure 2 below, a portion of the Bonaparte Basin is served by pipeline connectivity to Darwin, while the Carnarvon Basin is connected to the Perth domestic gas market via the Dampier-Bunbury pipeline. A LNG gas hub is proposed for the Browse Basin at James Price Point, approximately 80km north of Broome. The shale formations in both the Perth and Canning Basins occur at great depth, generally below 2500m.

The estimated recoverable reserves of naturally occurring hydrocarbons in Western Australian offshore basins are 156.9 tcf.[15] Onshore, the EIA estimates that the technically recoverable reserves of shale gas are 288 tcf.[16] Western Australia has demonstrably huge

[15] Western Australia Department of Mines and Petroleum, *Statistical Digest* (2010), 19.

[16] US Energy Information Administration, *World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States* (EIA, 2011),

SGR, double the recoverable offshore gas reserves. As such, it is inevitable that the recovery of SGR will dominate Western Australia in years to come. Given that well stimulation, including hydraulic fracturing is likely to be required to recover much of the recoverable SGR, there will be an increase in the use of fraccing, requiring an appropriate regulatory framework to ensure the effective regulation of shale gas activities.

6. REGULATION OF SHALE GAS ACTIVITIES AND FRACCING IN WESTERN AUSTRALIA

The role of the DMP in the shale gas activities in Western Australia

Since shale gas is ordinary natural gas, contained in formations that make recovery more difficult, the policy for the development of shale gas is the same as that for the development of all petroleum resources in Western Australia. The policy of the Western Australia Department of Mines and Petroleum is to provide a lead agency role in attracting investment in the exploration and development of the state's petroleum resources through the provision of geoscientific information on energy resources, and the management of an equitable and secure titles system. A clear policy, publically articulated, will assist WADMP in outlining its goals and strategies in the development of SGR.

As part of its policy to encourage the development of the state's energy resources, the Department of Mines and Petroleum encourages and facilitates responsible exploration and development of production of all petroleum resources. It administers and regulates petroleum exploration and production in accordance with the following Acts and the associated relevant regulations:

- Offshore petroleum activities in Commonwealth Waters: the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) (OPGGSA;
- Offshore petroleum activities in State Waters: *Petroleum (Submerged Lands) Act 1982* (WA) (PSLA); and
- Onshore petroleum activities: *Petroleum and Geothermal energy Resources Act 1967* (WA) (PAGERA).

Shale gas represents an unprecedented opportunity for Western Australia to establish security in energy supplies for the state, particularly for urban energy consumers in the greater Perth region. The Varanus Island incident and subsequent major interruption to gas resources in the Perth area highlighted the vulnerability a reliance on gas supply from the North West Shelf and transported along the Dampier-Bunbury Gas Pipeline.

Department of Mines and Petroleum estimates that the Perth Basin holds 9-12 tcf of recoverable shale gas resources within the vicinity of existing pipelines. This represents a significant gas resource for Perth, since 1 tcf of gas can provide enough energy to power a city of one million people for 20 years. The use of shale gas from the Perth Basin would provide much needed security of energy supply for the Perth region, independent of the North West Shelf.

Estimates of 288 tcf shale gas reserves in onshore basins in Western Australia provide unrivalled opportunities for the state to greatly expand its export of LNG resources. Much of the shale gas is found in the Canning Basin, which is located near the proposed LNG processing hub at James Price Point. The recovery of shale gas from the Canning Basin could link with gas recovery offshore, contributing significantly to LNG exports.

A major hurdle in the development in the development of SGR in WA is the public perception of gas recovery onshore. Coal Seam Gas recovery in Queensland has provided a very public perception of unconventional gas extraction, as illustrated in figure 4 below, which illustrates CSG wells in the Roma region in western Queensland. With an expected 40,000 wells to drilled in this region there is understandably conflicts in land use between agriculture and CSG.

Figure 4: CSG Wells in the Roma Region, Queensland. Source: http://wage.org.au/news/display/2036

When developing its Shale gas resources, Western Australia needs to be mindful of conflicting land use and landholder access in shale gas extraction areas. The Perth Basin will present challenges in managing land use conflict and land use access. Of particular difficulty will be the management of agriculture and tourism in the Margaret River region. The Canning Basin will present its own particular challenges. In particular, there will be a need to manage indigenous land use and native title claims with fraccing operations.

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 a combination of

1. *Legislative provisions contained within the PAGERA (objects clause)*
2. *A pre-emptive land use management strategy developed in consultation with relevant stakeholders and communities.*

Historical Use of Fraccing in Western Australia

Fraccing was established as a method of well stimulation for commercial use in gas wells since the 1940s. The technique has been used infrequently in Western Australia for over 40 years, to assist with the recovery of gas from conventional wells. In particular the micro fraccing processes has been utilised to recover the Barrow Island gas deposits since the 1970s.

Current Shale Gas Activities

The use of fraccing for the recovery of shale gas is a relatively recent phenomenon. The use of fraccing for well stimulation has been infrequently undertaken in Western Australia. To date six fraccing activities of onshore shale gas reservoirs have been approved – five in the Perth Basin, and one in the Canning Basin. In the Perth Basin, three wells have been fracced. In each well, fraccing occurred at depths greater than 2500m, substantially below aquifers, as demonstrated in figure 5 below.

Information Regarding Activities Targeting Shale and Tight Gas Resources

Location	Lease (s)	Current/Old Proponent of Lease	Wells	Status of Well	Target (prior to drilling)	Fracture Stimulation Conducted / Proposed	If conducted, between what depths (metres)
Perth Basin	EP 389	Empire Oil & Gas	Gingin West 1	Suspended	Tight Gas	No	-
	EP 408	Whicher Range Energy	Whicher Range 4 ST1	Sidetrack of WR4 proposed	Unconventional Gas	No	-
	EP 407	Latent/Transerv	Warro 3	Suspended	Tight Gas	Conducted	3876-4248
			Warro 4	Awaiting fracture stimulation		Proposed	#
	L 2	AWE	Corybas 1	Suspended	Tight Gas	Conducted	2515-2520
	EP 413	Norwest Energy	Arrowsmith 1	Suspended	Shale Gas	No	-
			Arrowsmith 2	Awaiting fracture stimulation		Proposed	#
	L4/L5	AWE	Woodada Deep 1	Awaiting fracture stimulation	Shale Gas	Proposed	#
Canning Basin	EP 391a	Buru Energy	Yulleroo 2	Suspended	Tight Gas	Conducted	2850-3100
	EP 371		Valhalla 2	Currently drilling	Unconventional Gas	No	-
	5/07-8EP	Oil Basins Ltd	Backreef 1	Completed	Shale Gas/Coal Seam Gas	No	-

LEGEND

- Wells targeting unconventional gas
- Wells targeting unconventional gas that have been (or will be) fracture
- # - The requested information is not yet available.

Figure 5: Shale and tight gas drilling activities in Western Australia to date, including wells using fraccing. Source: Compiled from WADMP Records

It is important to note that shale gas activities in Western Australia are still at the exploration and appraisal phase. There have been only a handful of wells drilled in the Perth and Canning Basin. All have been exploration wells, used to determine the extent of the shale gas reserves in that field. To date small players have undertaken the exploration activities in the shale gas basins. This presents particular challenges to WADMP as regulator, since these operators may not have the personal or corporate knowledge of well design that may be available to large, international companies. This places responsibility on WADMP as regulator to ensure that the fraccing operations are conducted in a manner that

will ensure the integrity of the wells and the management of produced water to avoid contamination of water resources.

Regulatory Framework for Onshore Shale Gas in WA

Onshore petroleum activities in Western Australia, including shale gas activities (since shale gas is the same gas as gas recovered from other reservoirs), are regulated under the *Petroleum and Geothermal Energy Resources Act 1967* (WA) (PAGERA) and the associated *Schedule of Onshore Exploration and Production Requirements – 1991* (the 'Schedule'). The schedule contains many provisions that are generally found in Regulations, including environment, drilling, reporting and data, regulation of production, geological and geophysical surveying and reporting requirements.

The Schedule was established in 1991 when there was a clear focus on the recovery of oil resources. Furthermore, the Schedule is prescriptive rather than objective-based, which is the basis for the regulation of petroleum activities today. The dated nature of the Schedule is illustrated by the definition of 'reservoir' in cl 105 – 'any porous and permeable rock that is capable of storing fluids and yielding them into a well'. Since gas is not a fluid, there is doubt whether the Schedule covers shale gas activities

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.*

Regulations attached to PAGERA include the *Petroleum and Geothermal Resources (Management of Safety) Regulations* (PAGER (MoS)R) and *Petroleum and Geothermal Energy Resources (Occupational Health and Safety) Regulations* (PAGER(OHS)R).

The PAGERA purports to regulate across the entire petroleum chain (outlined in figure 6 below), from the exploration, through appraisal, development and production phases to abandonment of the field as petroleum recovery operations cease.

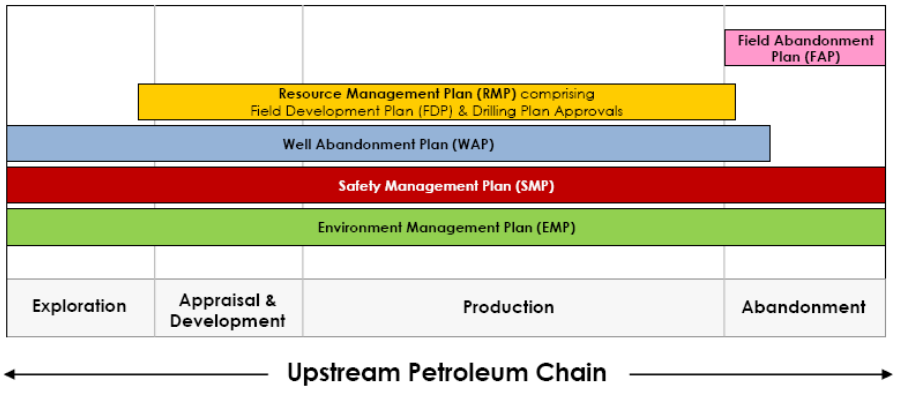


Figure 6: The Upstream petroleum chain. Source: Compiled by Author

The PAGERA regulates drilling of wells (Division 2), the grant of production licences (Division 3) and the registration of the titles (Division of 4), as well as providing general provisions under Division 5. Royalties and Fees are regulated in Division 7 of the PAGERA. However, the present PAGERA does not enable the development of petroleum resources on a basin –wide basis. As SGR are developed, there will be a challenge for the WADMP to ensure

that the resources are developed in a manner that ensures that field sterilisation does not occur. Therefore, part of the regulation of SGR should include an approach to licencing (exploration and production that minimises the risk of field sterilisation.

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.

Regulation of onshore petroleum resources is premised around three pillars:

- Safety;
- Environment; and
- Management and resource management, comprising field development, well drilling and abandonment, and field abandonment after field production has ceased.

These three pillars are illustrated in figure 7 below.

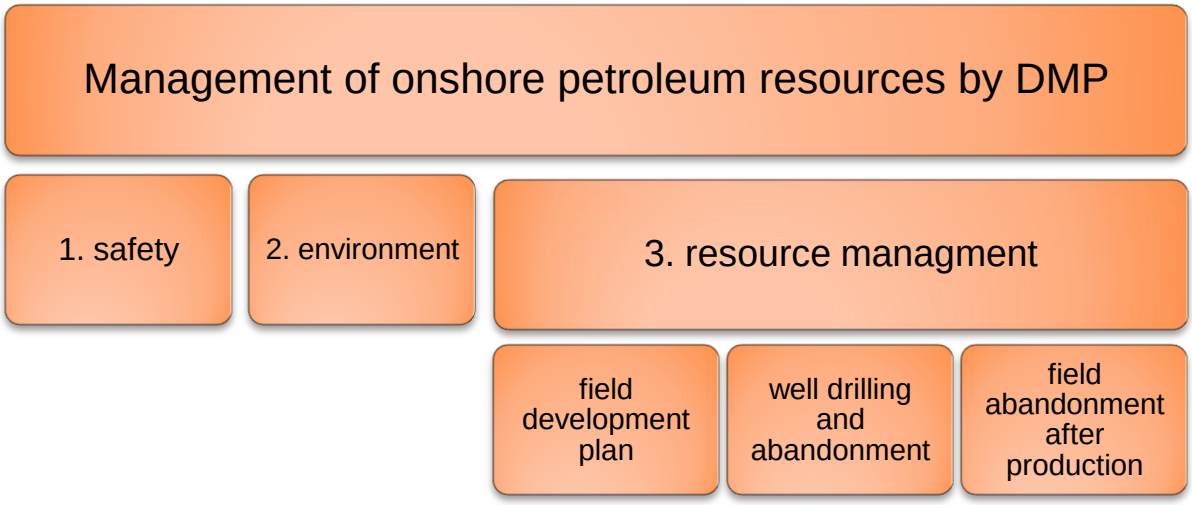


Figure 7: The regulation of the upstream petroleum chain at WADMP.
Source: Compiled by Author

1. Regulation of Safety in Shale Gas Activities

The safety of shore petroleum operations is regulated by comprehensive legislative provisions outlined in Part IIIA and Schedule 1 of the PAGERA. In addition, the PAGER(MoS)R and PAGER(OHS)R establish comprehensive regulations for the occupational health and safety of workers and the management of safety through the application of a safety case regime. Together these establish a comprehensive framework for the regulation of safety at onshore petroleum facilities.

The safety requirements for workers and facilities and workers are regulated by the Safety branch of the Department of Mines and Petroleum, not the Petroleum Division. Since safety is not regulated by the Petroleum Division of the Department of Mines and Petroleum there is a need for an assessment of the safety process and procedure by Petroleum division to

ensure that the regulation of safety for onshore petroleum operations is complementary to the management of resources undertaken by the Petroleum Division.

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 processes to ensure that there are complementarities and the current safety regulations apply across the petroleum chain for onshore shale gas activities.

2. Regulation of the Environment in Shale Gas Activities

There are no legal provisions in the Act that specifically pertains to the management of the environment in onshore petroleum activities. Environmental protection is provided under s95 of PAGERA, which confers authority on the Minister (or delegate) to give a direction to the leaseholder. Under this section, the direction to protect the environment arises from clause 114 of the Schedule. Under cl 114 (3), the operator is required to have an approved code of environmental practice relevant to the area of operations. At best this is an implied authority to demand an Environmental Plan (EP) or Environmental Management Plan (EMP). Otherwise, environmental protection (the requirement of an EMP or EP) is enforced as a condition of a title or an approval for an operation (eg. drilling or seismic).

Under the current legislative framework, the EP or EMP is legally unenforceable. The PAGERA requires compliance with a Direction under s 95. Failure to comply with a direction will result in a fine of $5000 or $10000 under s95(2c), s95(6) or s96. However, if an operator does not comply with a direction, there is no legislative provision to enforce that direction. At best, compliance could be achieved by cancelling the title. To date this has not occurred.

Whilst the legislative provisions requiring an environmental plan are weak, the internal DMP processes for environmental approval are rigorous. The process for the assessment and approval of an EP or EMP is defined at http://qms/Environment/Lists/Petroleum/ENV-PEB-001.pdf and reproduced in Appendix 1. The staff that execute the assessment of an EP/EMP are committed to maximising environmental protection, and utilise a set of internal processes to assess the environmental compliance for the proposed EP/EMP. The present rigorous environmental protection for onshore shale gas activities in Western Australia is a testament to the dedication of the staff of the environmental branch, the processes implemented and the creative use of the Schedule to enforce the requirement of an EMP. Legal enforceability for environmental matters is tenuous under the PAGERA. In order for the EMP to become legally enforceable, environmental regulations to regulate environmental aspects of shale gas extraction should be created as soon as possible.

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.

3. Resources Management

The regulation of each of these pillars is enables as a result of provisions of the PAGERA. In order to effectively regulate the complete petroleum chain, each pillar has developed regulatory process overviews that assist in the effective management of petroleum activities. An example of such a regulatory process is the *Petroleum Production Licence Approval Process Overview,* which is reproduced in Appendix 2, and can be found at

http://qms/PetroleumAndEnvironment/Lists/PetroleumTenureAndLandAccessBranch/PD-PTLA-OV-013%20(WEB).pdf. These process overviews are Quality Management System Certified to ISO 9001:2008 Standard. As such, most Petroleum and Land Access process overviews are standardised:

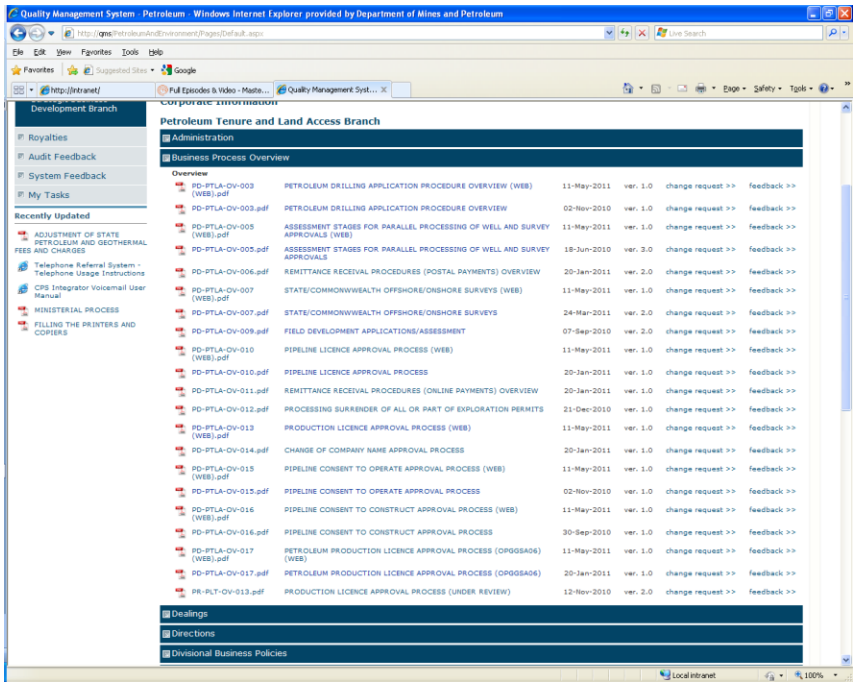


Figure 8: Business Process Overviews, Petroleum Tenure and Land Access Branch, Petroleum Division, Department of Mines and Petroleum.

Drilling Program Approvals

The drilling or fraccing of an onshore well is regulated in a manner similar to the regulation of EMP's. The regulation of drilling and workover is legislated under s95 of PAGERA, which confers authority on the Minister (or delegate) to give a direction to the leaseholder. Under this section, the direction to regulate drilling arises from Part V of the Schedule, and the operator is required to have an approved drilling program in order to undertake drilling operations. As a result of the unenforceable nature of the Schedule, the drill program under the current legislative framework is legally unenforceable. The PAGERA requires compliance with a Direction under s 95. Failure to comply with a direction will result in a fine of $5000 or $10000 under s95(2c), s95(6) or s96. However, if an operator does not comply with a direction implemented under the Schedule, including a drilling program, there is no legislative provision to enforce that direction.

Whilst the legislative provisions for enforcement of a drilling program are weak, the internal DMP processes for Drilling Program approval are rigorous. The process for the assessment and approval of a Drilling Program is reproduced in Appendix 3 and found at http://qms/PetroleumAndEnvironment/Lists/ResourcesBranch/PD-RES-ASM-005.pdf.

The staff that execute the assessment of a drill program are exceptionally experienced, committed to ensuring well integrity and best practice in well design. Furthermore, WADMP utilises a set of rigorous internal processes to assess the compliance of the integrity of the proposed drilling program, as illustrated in figure 9 below.

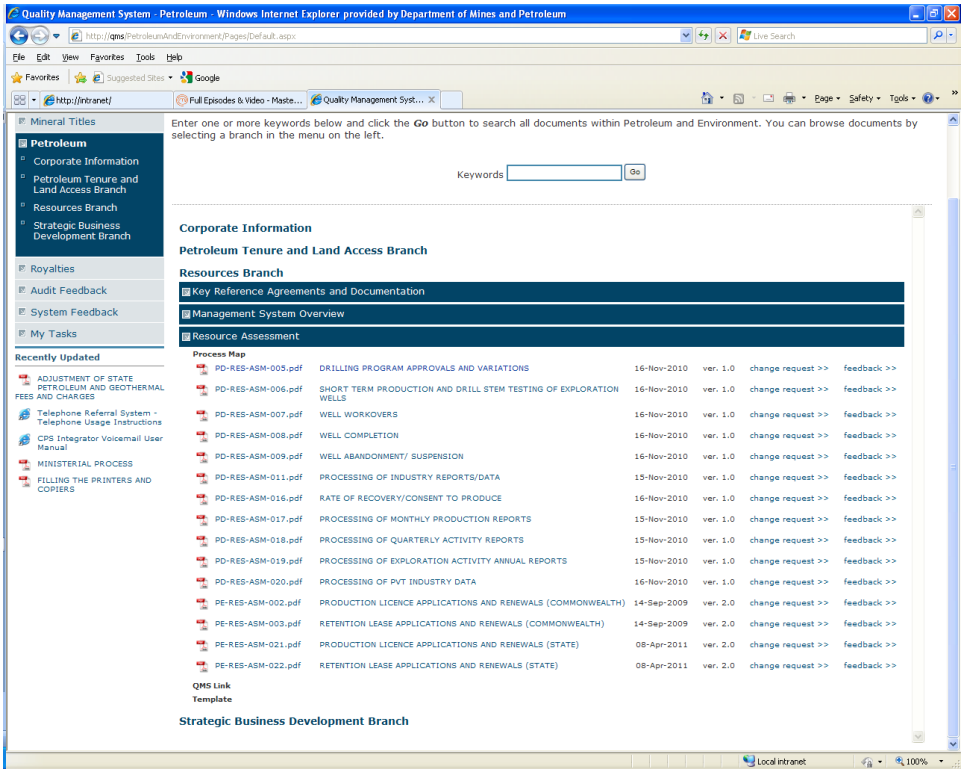


Figure 8: Process Maps for resources assessment, Resources Branch, Petroleum Division, Department of Mines and Petroleum.

The present rigorous processes and excellence in drill program approval for onshore shale gas activities in Western Australia arises due to the experience and commitment of the staff, which cannot be faulted. However the experience and dedication of the staff is also an achilles heel for the WADMP. Given the age of many of the senior staff, and the likely exponential increase in the number of wells requiring approval as shale gas exploration burgeons, the WADMP needs to be aware of the need for a succession plan in the Resources Branch, to ensure that corporate knowledge is passed on. Furthermore the history of fraccing and well design should be captured as corporate memory. Finally, all relevant technical information and experiences that are used by senior staff when appraising and approving drill programs should also be captured for use by the department.

In order for drill programs executed under the Schedule to become legally enforceable, Resource Management Regulations should be drafted. An important area of consideration in the approval of a drilling program is the necessary consideration of the spacing of wells in areas of seismicity. Given the vast area of the state, the complex geology and the variety of geological basins, it would be inappropriate (not to mention impossible) to legislate for the spacing of wells to prevent seismic effects of the fraccing process. However, it would be

prudent that any resource management regulations that were implemented should necessary legislate that the seismicity of an area should be taken into consideration when planning the drill program, and in particular the spacing of the wells.

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.

Recommendation 10: The WADMP undertake to write resource regulations to regulate onshore petroleum activities, including the recovery of coal seam gas.

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.

Well abandonment

Well abandonment can occur at any stage of the upstream petroleum chain. Generally wells are abandoned in exploration and appraisal phases of the petroleum chain, although wells are also abandoned during the production phase.

The abandonment of the well is considered and approved as part of the drill program approval process. Usually this is adequate, since well abandonment is relatively straightforward in most formations. However, in shale gas wells that have been fracced, there is the added need to regulate water that has been produced from the abandoned well. At present neither the PAGERA or the Schedule addresses the need to regulate this water. The management of such water should form part of an EMP; however there is limited capacity to enforce a management plan. Therefore as part of the writing of regulations for the management of onshore petroleum activities,

Recommendation 12: The WADMP ensure the inclusion of management of produced water from abandoned wells in the proposed Environment Regulations and the Resource Management Regulations.

Abandonment of Licence Area

The PAGERA fails to address the abandonment of a licence area after the area has either completed production, or abandoned due to lack of prospectivity. This is likely attributable to the WADMP in a phase of encouragement of exploration development and production. To date there has not been the abandonment of an onshore tenure. This is demonstrated by the absence of a standard Petroleum and Land Access process overview for the abandonment of a field.

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.

Recommendation 14: The WADMP develop a standard Petroleum and Land Access process overview for the abandonment of a field.

Relevance of Queensland's resource management regulation framework

In 2011 the Queensland Department of Environment and Resource Management (DERM) established an LNG Enforcement Unit (LNGEU). This unit was established to monitor CSG operators and operations, to ensure compliance with laws and policies that affect the extensive LNG industry in that state.

The strength of the LNGEU is the multi-disciplinary nature of the unit, comprising staff from DERM and the Department of Employment, Economic Development and Innovation (DEEDI). It includes environmental, groundwater petroleum and gas safety specialists, as well as staff specialising in land access issues.

The major role of the LNGEU is the regional coordination of compliance activities and a whole-of-government approach to managing complaints. It is designed to act as a one-stop shop to respond to, land access, and environmental concerns for CSG issues, as well as managing and investigating complaints relating to CSG activities.

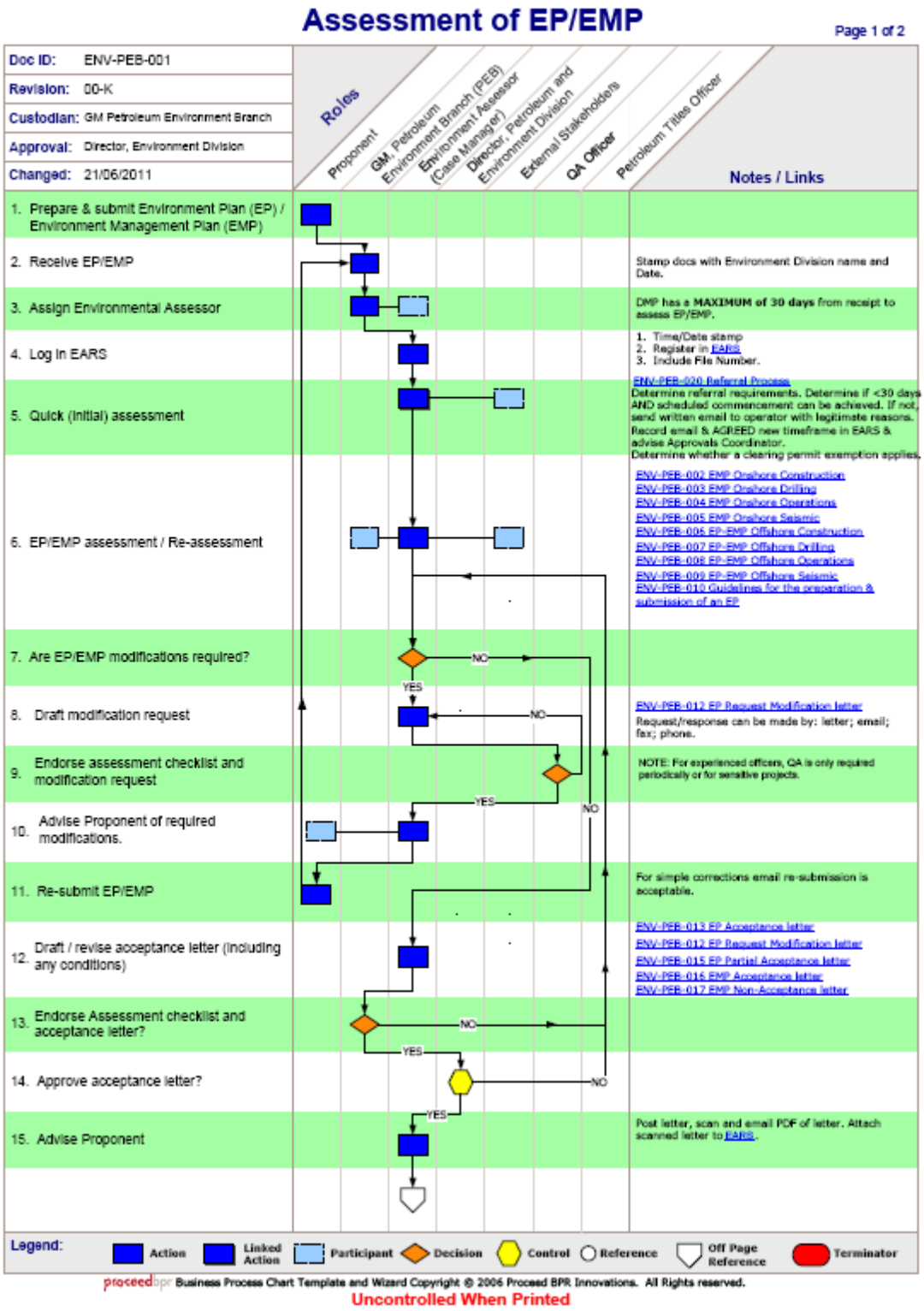
The scale of CSG operations in Queensland (over 40,000 wells are expected to be drilled in the next five years) and the organisational structure for the regulation of CSG and LNG activities in Queensland has necessitated the establishment of the LNGEU. However, the regulatory processes and standards that have been implemented by WADMP, and the relationship between resources, titles, environment and safety sections of the Petroleum Branch of WADMP at present provides adequate processes for the assessment of shale gas applications. Furthermore, the low number of wells that are presently subject to fraccing does not warrant the establishment of a similar LNGEU in WA.

Should the nature of the relationship between the relevant sections of the Petroleum Branch of the WADMP or the regulatory processes and standards alter, it would be necessary for the WADMP to reconsider the establishment of a LNGEU similar to that established in Queensland. In addition, should there be a dramatic, exponential increase in the number of onshore fraccing to be drilled in onshore basins, it may be necessary for the WADMP to establish such a unit.

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.

7. APPENDICES

APPENDIX 1



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Assessment of EP/EMP

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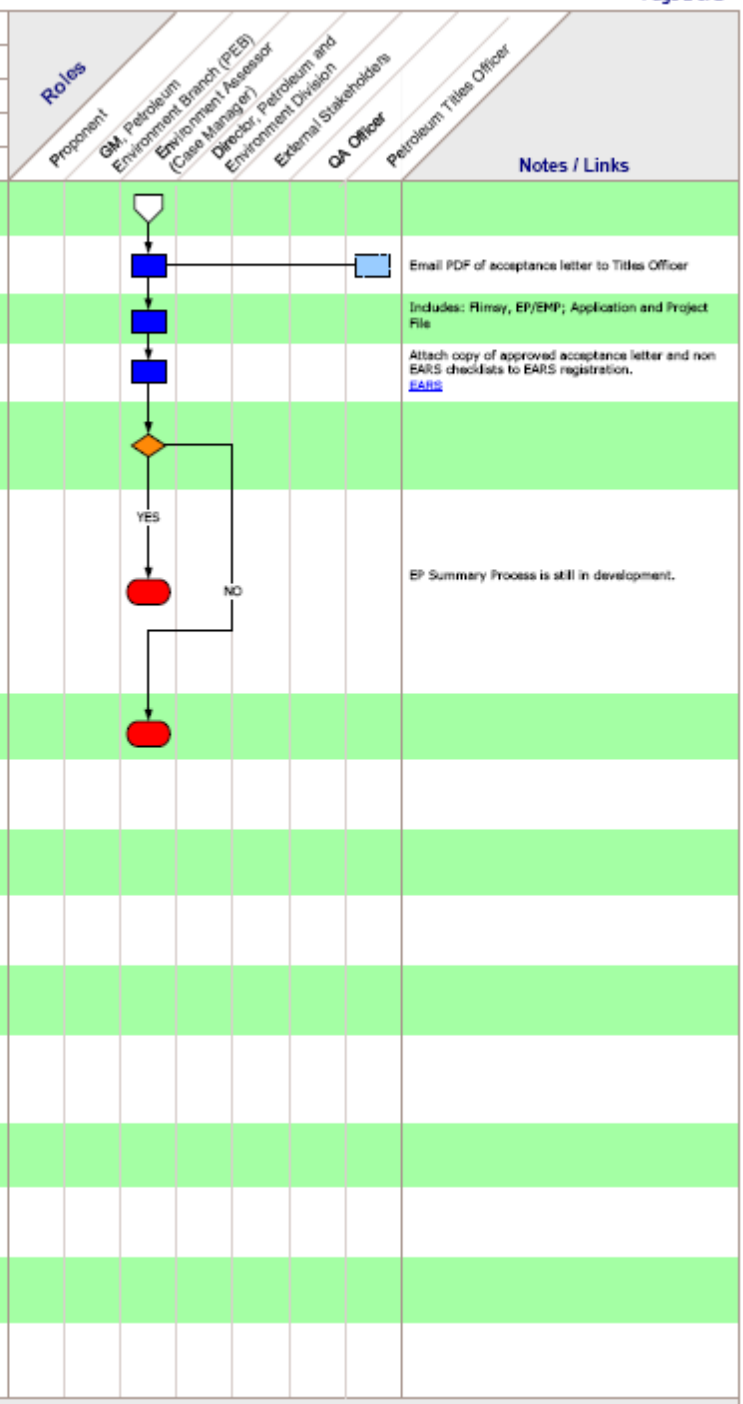

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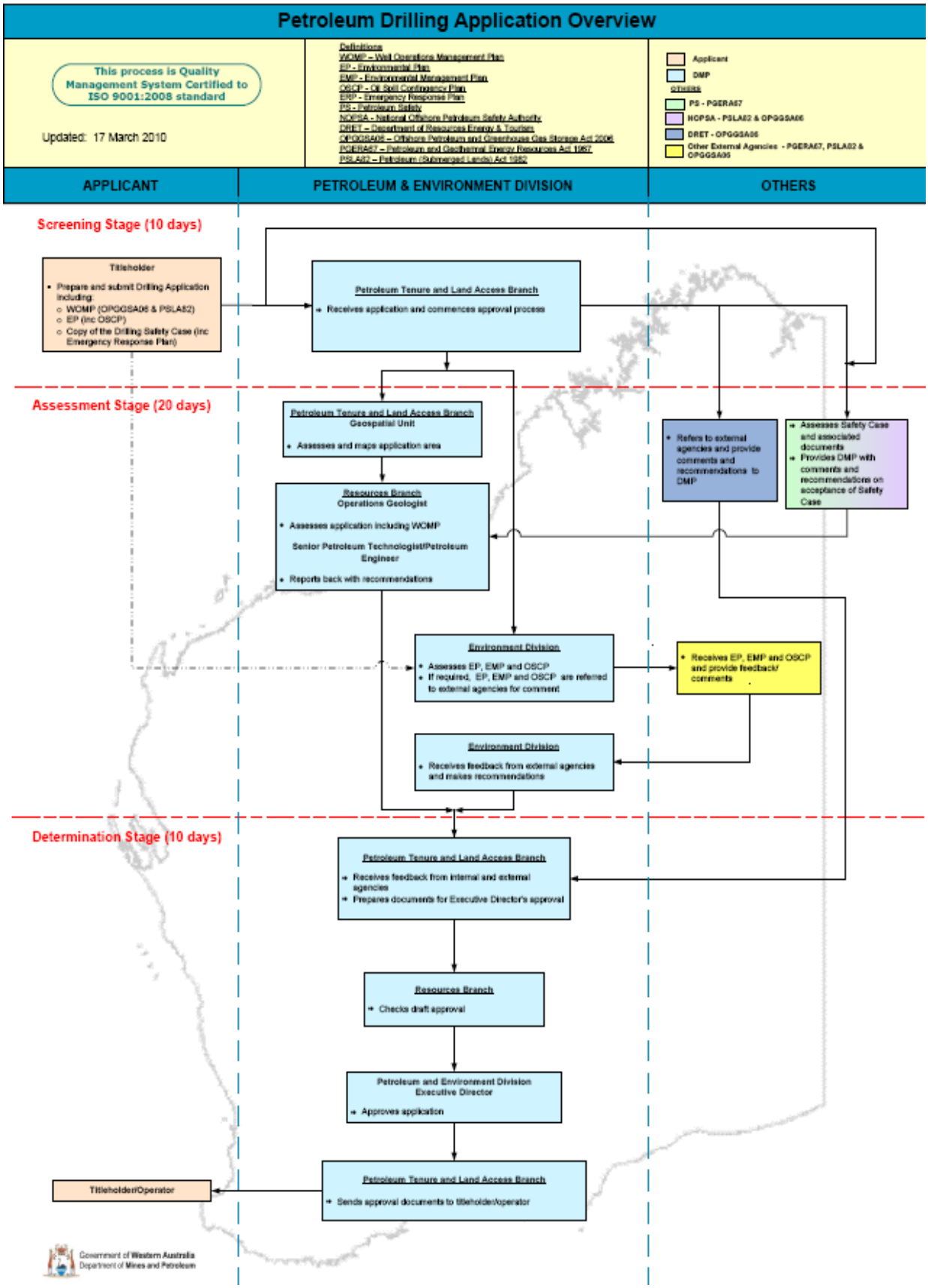
APPENDIX 2


Petroleum Drilling Application Overview
This process is Quality Management System Certified to ISO 9001:2008 standard
Updated: 17 March 2010
Definitions
WOMP – Well Operations Management Plan
EP - Environmental Plan
EMP - Environmental Management Plan
OSCP - Oil Spill Contingency Plan
ERP - Emergency Response Plan
PS - Petroleum Safety
NOPSA - National Offshore Petroleum Safety Authority
DRET – Department of Resources Energy & Tourism
OPGGSA06 – Offshore Petroleum and Greenhouse Gas Storage Act 2006
PGERA67 – Petroleum and Geothermal Energy Resources Act 1967
PSLA82 – Petroleum (Submerged Lands) Act 1982
Applicant
DMP
Others
PS - PGERA67
NOPSA - PSLA82 & OPGGSA06
DRET - OPGGSA06
Other External Agencies - PGERA67, PSLA82 & OPGGSA06
APPLICANT
PETROLEUM & ENVIRONMENT DIVISION
OTHERS
Screening Stage (10 days)
Titleholder
Prepare and submit Drilling Application including:
WOMP (OPGGSA06 & PSLA82)
EP (inc OSCP)
Copy of the Drilling Safety Case (inc Emergency Response Plan)
Petroleum Tenure and Land Access Branch
Receives application and commences approval process
Assessment Stage (20 days)
Petroleum Tenure and Land Access Branch
Geospatial Unit
Assesses and maps application area
Refers to external agencies and provide comments and recommendations to DMP
Assesses Safety Case and associated documents
Provides DMP with comments and recommendations on acceptance of Safety Case
Resources Branch
Operations Geologist
Assesses application including WOMP
Senior Petroleum Technologist/Petroleum Engineer
Reports back with recommendations
Environment Division
Assesses EP, EMP and OSCP
If required, EP, EMP and OSCP are referred to external agencies for comment
Receives EP, EMP and OSCP and provide feedback/ comments
Environment Division
Receives feedback from external agencies and makes recommendations
Determination Stage (10 days)
Petroleum Tenure and Land Access Branch
Receives feedback from internal and external agencies
Prepares documents for Executive Director's approval
Resources Branch
Checks draft approval
Petroleum and Environment Division
Executive Director
Approves application
Petroleum Tenure and Land Access Branch
Sends approval documents to titleholder/operator
Titleholder/Operator
Government of Western Australia
Department of Mines and Petroleum

APPENDIX 3

DRILLING PROGRAM APPROVALS AND VARIATIONS

Page 1 of 1

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Revision:	5
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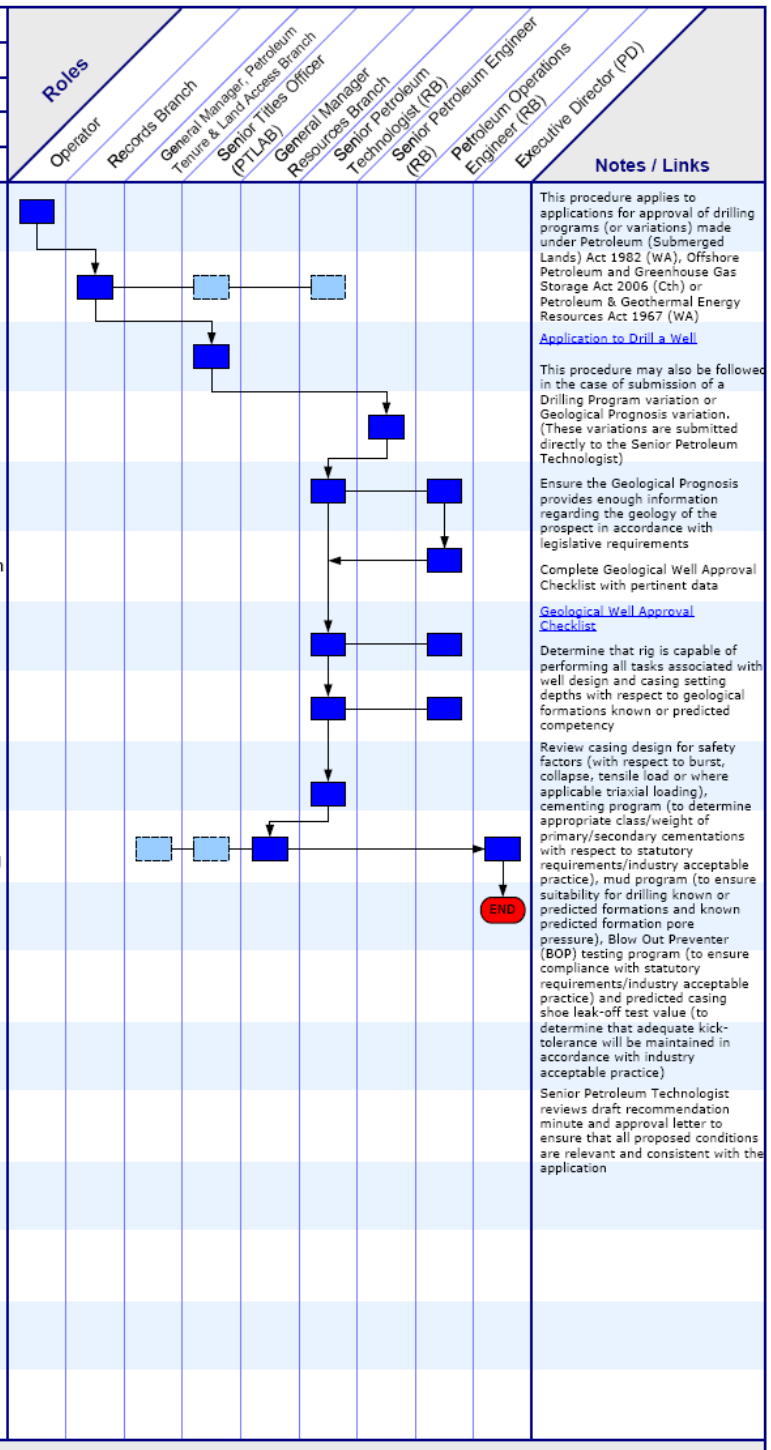
Approval:	General Manager Resources Branch
Changed:	15/11/2010



Legend: Action | Linked Action | Participant | Decision | Control | Reference | Off Page Reference | Terminator

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