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Regulatory Nirvana for Hydraulic Fracture Stimulation

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Additional information is available at the end of the chapter

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Abstract

Government are challenged to deploy trustworthy regulation to enable profitable and environmentally sustainable unconventional petroleum projects. A key activity under scrutiny during the development of these projects is hydraulic fracture stimulation. Regulatory 'Nirvana' for unconventional projects and conventional projects alike entails:

- Pragmatic licence tenure;
- Regulatory certainty and efficiency without taint of capture;
- Regulators and licensees with trustworthy competence and capacity;
- Effective stakeholder consultation well-ahead of land access;
- Public access to details of significant risks and reliable research to backup risk management strategies so the basis for regulation is contestable anytime, everywhere;
- Timely notice of entry with sufficient operational details to effectively inform stakeholders;
- Potentially affected people and organisations can object to land access - without support for vexatious objections;
- Fair and expeditious dispute resolution processes;
- Fair compensation to affected land-users;
- Risks are reduced to low or as low as reasonably practicable (ALARP) while also meeting community expectations for net outcomes;

- Licensees monitor and report on the efficacy of their risk management, and the regulator probes same;
- Regulator can prevent and stop operations, require restitution, levy fines and cancel licences; and
- Industry compliance records are public, so the efficacy of regulation is transparent.

These principles are deployed in South Australia where:

- 24 unconventional gas plays are being explored, each with giant gas potential;
- Hundreds of wells have been safely hydraulically fracture stimulated;

Since implementing South Australia's *Petroleum and Geothermal Energy Act 2000* [1] (PGE Act), more than 11,000 notices of entry for petroleum operations led to just one court action, and that was to establish a legal precedent that geophysical surveys can extend outside a licence to enable a complete understanding of the potential resources within a licence.

The introduction of new energy development technologies is inevitable, so regulatory Nirvana requires adaptive learning so that the previously mentioned principles are maintained. Expedient, welcomed access to land for compatible, multiple uses is the metric for performance, and leading practice is based on the principle that trust is the most valuable lead factor and lag outcome in sustaining land access for resource exploration, development and production.

1. Introduction

The Australian oil and gas industry has contributed greatly to the economic prosperity and quality of life of our communities for decades to date. An opportunity to prolong and expand welcomed contributions in a golden age of unconventional gas is arising. The challenges ahead of a prospective golden age of unconventional gas are many, and include getting regulation and operations right. Results that consistently, simultaneously meet community and investor expectations for social, environmental and economic outcomes will deliver trust in land access and investment – and create a virtuous lifecycle for the upstream petroleum sector for decades to come.

Coal seam methane was Australia's first unconventional gas play to be commercialised and reserves will underpin LNG exports from Gladstone, Queensland. In October 2012, the tap was turned on the first domestic commercial use of shale gas from Moomba 191 in the Cooper Basin – another milestone on the road to develop a variety of unconventional gas resources across Australia. Foreseeing the potential scope of development of unconventional gas resources:

- Companies have shifted budgets to explore, appraise and develop unconventional gas plays;

- People and organisations potentially affected by unconventional gas operations have justifiably expressed concerns for preserving social, natural and economic environments; and
- Governments have made strides to refine regulatory and investment settings to simultaneously satisfy both community and investor expectations for net outcomes.

In this regard, October 2010, the South Australian Government's Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) initiated a consultative group to inform how unconventional gas projects could be undertaken the most sustainably and efficiently, considering the social, environmental and economic impacts and benefits. This group – the Roundtable for Unconventional Gas Projects in South Australia (Roundtable) – played a critical role, informing our Roadmap for Unconventional Gas Projects in South Australia (Roadmap) [2]. As of January 2013, the Roundtable had 230 members including peak representative bodies, companies, universities, media outlets, individuals and key government agencies from all the states, the Northern Territory and the Commonwealth governments. This paper summarises the findings of this Roadmap that relate to world leading practices for the regulation of the development of unconventional petroleum resources that rely on hydraulic fracture stimulation to attain economic flow rates.

2. The Roadmap

The Roadmap for Unconventional Gas Projects in South Australia [2] was developed to provide timely, credible information to people, communities and markets, outlining potential risks and rewards associated with unconventional gas projects. It sets the course for the environmentally sustainable development of South Australia's large endowment of unconventional gas, and encourages safe exploration and production under this State's robust and effective regulatory framework, the PGE Act. The Roadmap helps to ensure people and enterprises potentially affected by unconventional gas projects understand the regulatory framework, the transparent environmental assessment and activity approval processes; and how they will be consulted, so their rights to object in part or in full are supported. The Roundtable also identifies 125 recommendations which cover the life cycle of unconventional gas projects – from exploration to production and possible liquefied natural gas exports, as well as related supply chains and infrastructure matters. Roundtable working groups have reconvened to develop plans to implement these recommendations.

To comment on and further inform the implementation of the 125 recommendations posed in the Roadmap or to enquire regarding participation in the Roundtable for Unconventional Gas Projects in South Australia – readers are asked to contact dmitre.petroleum@sa.gov.au.

3. Regulation to enable hydraulic fracture stimulation in the public's interest – The South Australian approach

Onshore petroleum exploration and development activities in South Australia are administered by DMITRE under the South Australian PGE Act. The PGE Act has a number of aspects

that are considered a comparative advantage without precedent in other Australian legislation [3]. High level objectives of the PGE Act include:

- Sustain trusted practical, efficient, effective and flexible regulation for upstream petroleum, geothermal and gas storage enterprises, and the construction and operation of transmission pipelines, in the State;
- Encourage and maintain competition in the upstream petroleum and geothermal sectors;
- Minimise environmental damage and protect the public from risks inherent in petroleum and geothermal operations;
- Sustain effective consultation processes with people affected by regulated activities, and the public in general; and
- Ensure as far as reasonably practical the security of supply of natural gas.

It is important in this discussion to highlight that in the context of the PGE Act the definition of environment (under s. 4 of the PGE Act) is broad, and includes:

- Land, air, water (including both surface and underground water)
- Organisms and ecosystems – this includes native vegetation and fauna;
- Buildings, structures and cultural artefacts;
- Productive capacity or potential;
- The external manifestations of social and economic life which includes aspects such as human health and wellbeing; and
- The amenity values of an area.

This definition of environment is consistent with the *Environment Protection Act 1993* [4] definition, and is broad to ensure that potential impacts on all natural, social and economic aspects of the environment are identified, considered, and appropriately addressed through the environmental assessment and approval provisions of the PGE Act.

A key lesson learnt by DMITRE in post-event investigations of significant incidents is that regulators must have relevant and up-to-date capabilities (competence and capacity) to be trusted to act in the interests of the many stakeholders involved in upstream petroleum industry activities. This includes protecting natural, social and economic environments; effectively managing the risks of regulatory capture [5]; and providing expeditious approvals. As the regulator of upstream petroleum and geothermal energy activities in South Australia, administering the PGE Act, DMITRE strives to maintain a one-stop-shop or lead agency approach.

This approach has been discussed by Australia's Productivity Commission [6] which concluded:

- One-stop-shops (lead agencies) are the most efficient regulatory approach when well managed without capture;

- Under a lead agency approach ... approval of most, if not all, aspects of an application would rest with one designated agency. This agency ... would maintain control of the process and in most cases, would consult with other relevant agencies, such as an environmental agency, rather than formally refer the application to a separate agency for assessment. In some limited circumstances where impacts are considered to be significant, a formal referral may take place. By maintaining control of the approval process the lead agency approach is able to streamline approval processes and minimise time delays.
- South Australia's one-stop-shop (through DMITRE), 'is widely seen as a model for other jurisdictions to emulate';
- With appropriate governance, experience in South Australia suggests that [lead agencies] can achieve an appropriate balance between enforcing legislative provisions and expediting approvals.

Properly resourced one-stop-shops (lead agencies) transparently facilitate the delivery of all co-regulatory objectives and requirements, and hence earn trust from the industry, co-regulatory agencies and the public. A one-stop-shop approach enables stewardship of approval processes in parallel rather than in series.

Through this approach DMITRE works closely with its co-regulatory agencies, such as the South Australian Environment Protection Authority (EPA), Department of Environment, Water and Natural Resources (DEWNR), SafeWork SA, Department of Health, Department of Planning, Transport and Infrastructure (DPTI) and Aboriginal Heritage to deliver an efficient application of all relevant laws and regulations applicable to the petroleum and geothermal industries in South Australia.

The PGE Act has been designed to enable a one-stop shop approach such that in complying with the objectives of the PGE Act, upstream petroleum operations' compliance with obligations under other legislation will also be facilitated. These concurrent legislation and requirements include:

- The Commonwealth's *Environmental Protection, Biodiversity and Conservation Act 1999* (EPBC Act) internationally important flora, fauna, ecological communities and heritage places – defined in the EPBC Act as matters of national environmental significance. The Commonwealth Government Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) provides stewardship for the EPBC Act;
- South Australia's *Environment Protection Act 1993* (EP Act), and relevant policies that provide the regulatory framework to protect South Australia's environment, including land, air and water. This legislation was the result of the streamlined integration of six Acts of Parliament and the abolition of the associated statutory authorities. South Australia's EPA provides stewardship for this Act;
- South Australia's *National Parks and Wildlife Act 1972* (NP&W Act), which is the cornerstone for protecting natural environments within parks and regional reserves in the State. The DEWNR provides stewardship for this Act. The NP&W Act is significant as it is a key part

of the co-regulatory approval regime for minerals and energy (including unconventional gas) resource exploration and production in South Australia;

- The South Australian *Work Health and Safety Act 2012* (SA) (WHS Act) is the state's lead legislation to protect people in the workplace. SafeWorkSA provides stewardship for this Act;
- The South Australian *Native Vegetation Act 1991* (NV Act), administered by DEWNR;
- The South Australian *Natural Resources Management Act 2004* (NRM Act), administered by DEWNR;
- The South Australian *Development Act 1993*, administered by the DPTI;
- The South Australian *Public and Environmental Health Act 1987*, and specifically the *Public and Environmental Health (Waste Control) Regulations 2010*, as administered by HealthSA
- The *Native Title (South Australia) Act 1994*, administered by the State's Attorney General's Department
- The Commonwealth *Native Title Act 1993* (NT Act) administered by the Commonwealth's Attorney General's Department
- The South Australian *Adelaide Dolphin Sanctuary Act 2005*, administered by DEWNR
- The *South Australian Aboriginal Heritage Act 1988* administered by the State's Department of Aboriginal Affairs and Reconciliation
- *The South Australian Marine Parks Act 2007* administered by DEWNR
- *The South Australian River Murray Act 2003* administered by DEWNR; and
- *The South Australian Arkaroola Protection Act 2012* administered by DEWNR.

Compliance with these pieces of legislation is facilitated through collaborations and working arrangements between DMITRE and the government agencies that administer these Acts, to ensure that the Statements of Environmental Objectives (SEO) that must be complied with for specific activities are consistent and in keeping with the relevant objects of each of these Acts

4. Principles for best practice regulation

The PGE Act was developed on the basis of the following 6 principles for regulatory best practice:

1. **Certainty.** The regulatory objectives are uniform, clear, and predictable for all stakeholders.
2. **Openness.** Stakeholders are appropriately consulted on the establishment of the regulatory objectives.

3. **Transparency.** The regulatory decision-making processes are visible and comprehensible to all stakeholders and industry performance in terms of compliance with the regulatory objectives is clear to all stakeholders.
4. **Flexibility.** The level of regulatory scrutiny, surveillance and enforcement needed to ensure compliance is determined on the basis of individual company compliance capability and the outcomes to be achieved.
5. **Practicality.** The regulatory objectives are achievable and measurable.
6. **Efficiency.** The compliance costs imposed on both government and the licensee by the regulatory requirements are minimised and justified. Negative impacts on communities are minimised, and licensees remain liable for the cost of their impacts. Furthermore, an appropriate rent (Royalty) is paid to the community from the value realised from the development and production of its natural resources.

The above listed Regulatory Principles can be achieved through the following regulatory strategies.

- Regulatory objectives and assessment criteria for those objectives are developed through broad stakeholder consultation involving industry, government agencies and the community to ensure acceptance and credibility in the environmental objectives to be achieved
- Regulators and licensees maintain trustworthy capabilities (competence and capacity)
- Effective, informative stakeholder consultation by both project operators and regulators is initiated well ahead of land access. This drives operators to explain their planned activities and any potential risks, seek feedback on areas of interest or concern for the community, and establish relationships and terms for land access with stakeholders well before applying for activity approval from DMITRE, e.g. before any particular activity 'gets personal'
- Provide public access to details of risks, reliable research to reduce key uncertainties and support risk management strategies so the basis for regulation is contestable
- Timely notice of entry with sufficient operational details to effectively inform stakeholders
- Potentially affected people and organisations can object to land access – while the regulator and prescribed dispute resolution processes do not support, and hence minimise, vexatious objections
- Fair and expeditious dispute resolution processes
- Fair compensation to affected land-users for costs, losses, and deprivation of land use due to operations
- Reduction of risks to low or as low as reasonably practicable (ALARP), while also meeting community expectations for overall outcomes
- Licensees monitor and report (to the regulator) on the efficacy of their risk management processes, and the regulator probes same

- The regulator can prevent and stop operations, require restitution or rehabilitation, levy fines and cancel licences
- Industry compliance records are made public, so the efficacy of regulation is transparent.

Clear, efficient and effective activity approval processes are fundamental for trustworthy regulation. Mapping approval processes can also elucidate scope for increased efficiency and reduced red tape. Figures 1, 2 and 3 illustrate the three-stage process for petroleum and geothermal licensing and approvals in South Australia with a one-stop-shop approach led by DMITRE, for exploration, retention, production and associated activities.

The first stage (Figure 1) entails the grant of a licence authorising the licensee to carry out specific activities to which the licence relates. Environmental assessments are required in the second stage (Figure 2). Statements of Environmental Objectives (SEOs) and environmental assessment criteria for activity approvals are established in this second stage. Finally, in the third stage (Figure 3), a location-specific activity notification is submitted for assessment and approval, where required.

All three stages are required to be completed before regulated activities can commence. In practice, it is possible for some aspects of each stage to progress in parallel. This flexibility is most easily enabled through discussions with the regulator (DMITRE) early in the planning process. Figures 1, 2 and 3 specify relevant regulations (of the PGE Act) to help guide licensees through these stages.

The proceeding sections describe stage 2 (Figure 2) and stage 3 (Figure 3). For details of license authorisation (stage 1) – refer to [2].

5. Environmental assessment and approval

The grant of a PGE Act licence does not provide an automatic entitlement to conduct operations. Rather, regulated activities under the PGE Act (under s. 96) may not be carried out unless an approved Statement of Environmental Objectives (SEO) is in place, prepared on the basis of an Environmental Impact Report (EIR).

The EIR identifies all potential impacts and their risks relating to the activity and the proposed risk mitigation strategies. The SEO identifies the environmental objectives to be achieved to address the risks identified in the EIR and the criteria to be used to assess achievement of the objectives.

Through the consultation requirements of the PGE Act, DMITRE expects that licensees will initiate consultation with stakeholders, generally through information sessions or meetings prior to and during the development of their EIR and SEO, to describe their planned activities and the potential impacts, positive or otherwise, which may be experienced by the stakeholders. This is also an opportunity for the licensee to respond to any queries that their stakeholders may have and to understand stakeholder concerns, to ensure that they are addressed within the EIR and SEO.

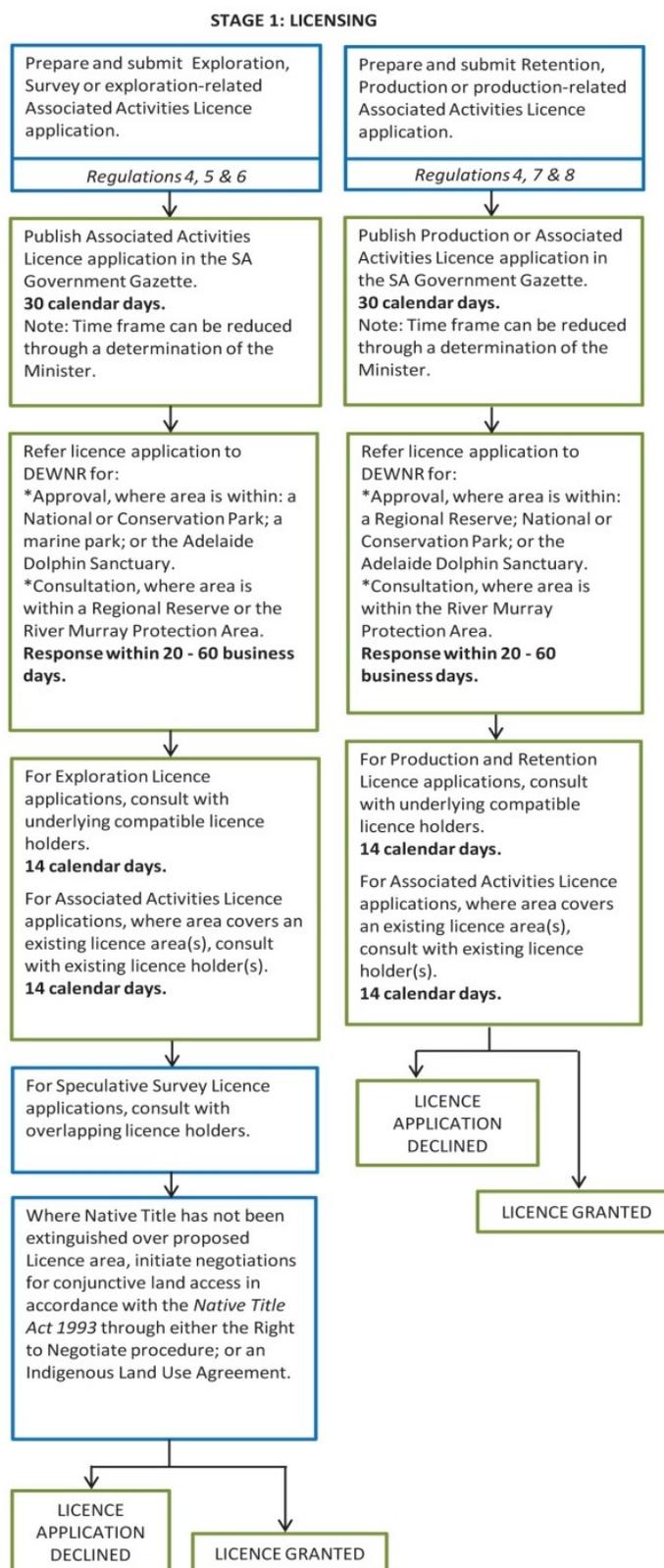


Figure 1. of licensing and approval process for exploration, retention and production activities pursuant to South Australia's *Petroleum and Geothermal Energy Act 2000*. (Blue box = initiated by proponent/Licensee and Green box = initiated by DMITRE/ SA Government)

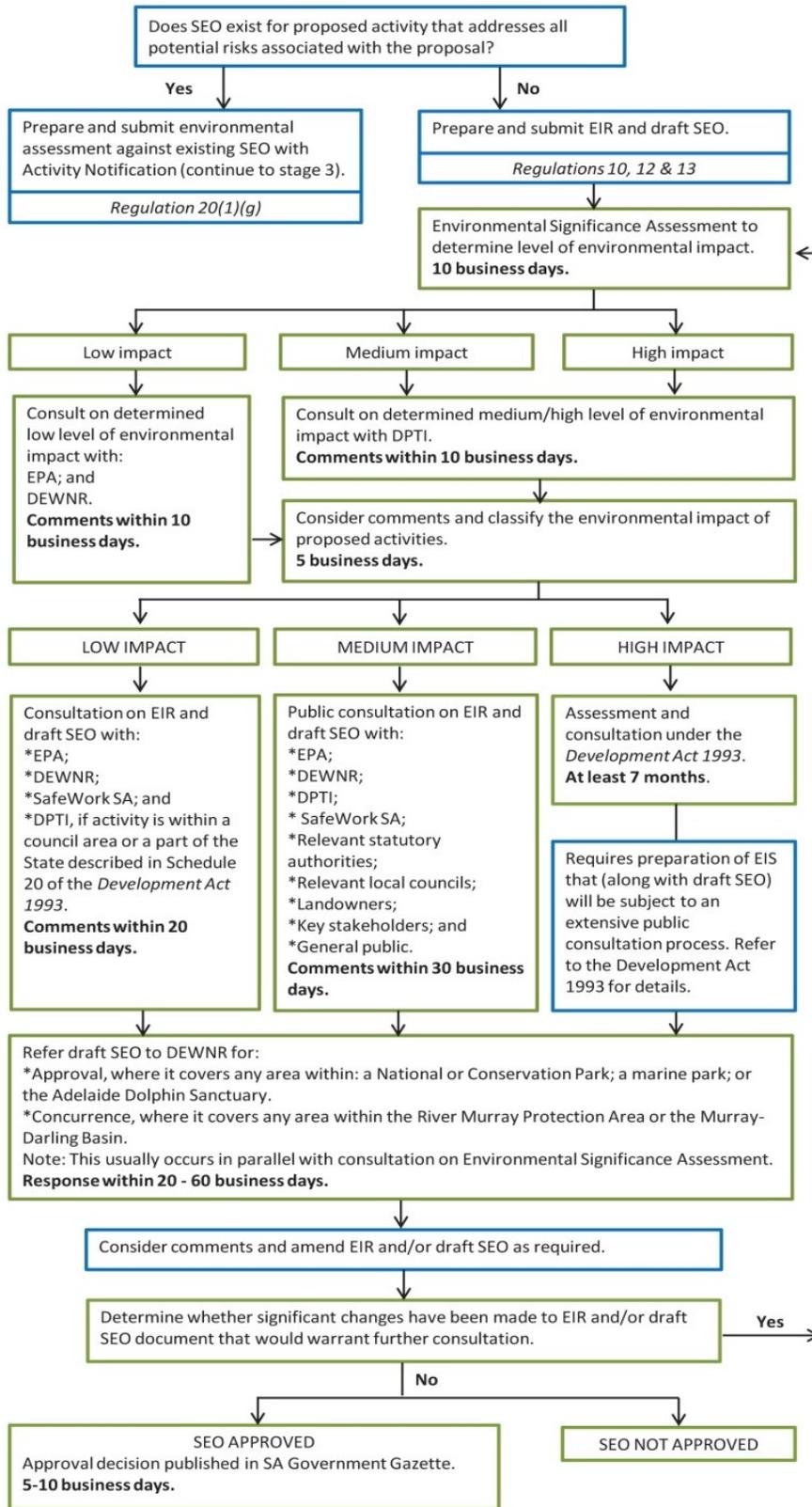
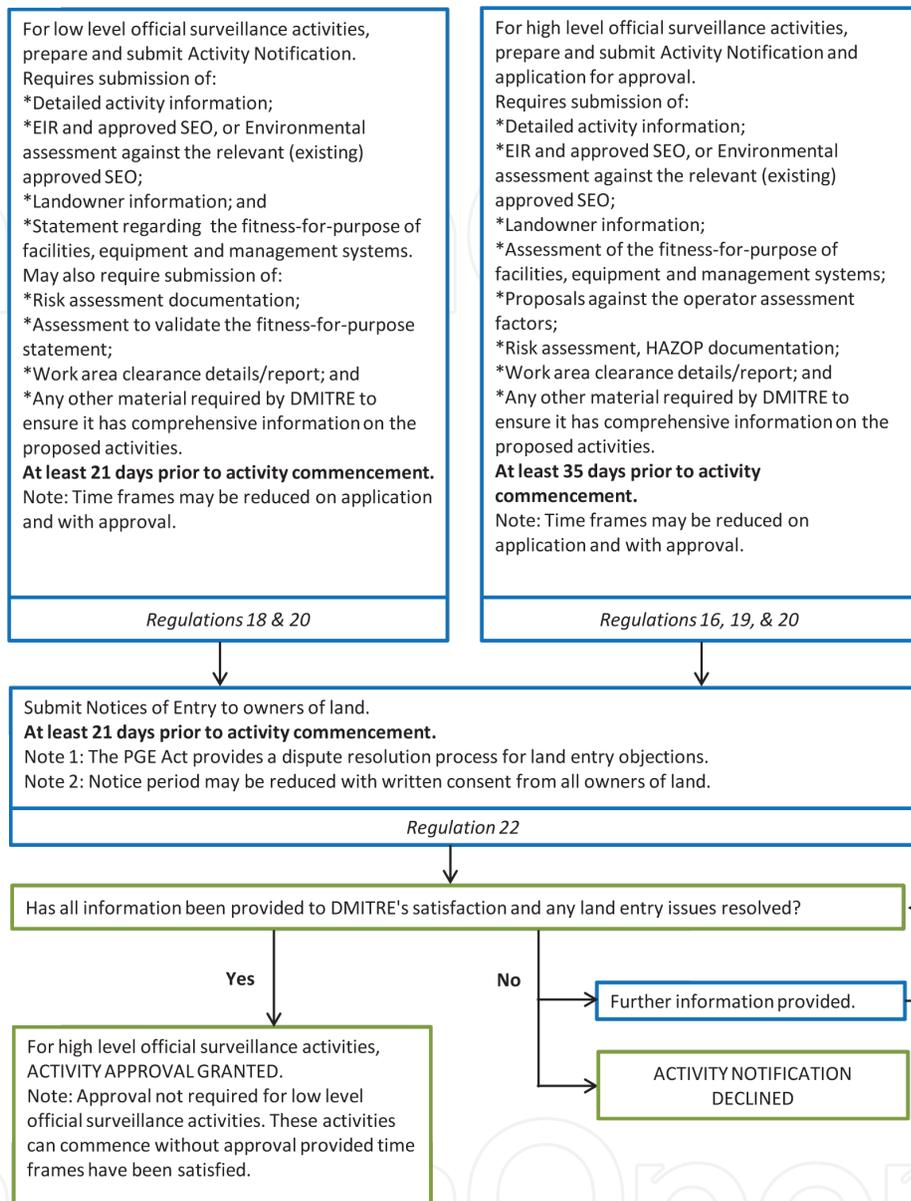


Figure 2. Stage 2 of licensing and approval process for exploration, retention and production activities pursuant to South Australia’s Petroleum and Geothermal Energy Act 2000. (Blue box = initiated by proponent/Licensee and Green box = initiated by DMITRE/ SA Government)

STAGE 3: ACTIVITY NOTIFICATION AND APPROVAL



DEWNR = Department of Environment, Water and Natural Resources
 DMITRE = Department for Manufacturing, Innovation, Trade, Resources and Energy
 DPTI = Department of Planning, Transport and Infrastructure
 EIR = Environmental Impact Report
 EIS = Environmental Impact Statement
 EPA = Environment Protection Authority
 HAZOP = Hazard and Operability Study
 PGE Act = Petroleum and Geothermal Energy Act 2000
 SA = South Australia
 SEO = Statement of Environmental Objectives

Blue box = initiated by proponent/
Licensee

Green box = initiated by DMITRE/
SA Government

Version 4: August 2012

Figure 3. Stage 3 of licensing and approval process for exploration retention and production activities pursuant to the *Petroleum and Geothermal Energy Act 2000*.

Other agencies with the duty of care for ensuring the objects of the legislation that they administer are met are also consulted early to ensure their requirements are included within the objectives detailed in the SEO.

Once an EIR and draft SEO have been prepared and submitted for assessment, DMITRE uses the information provided in the EIR to complete an environmental significance assessment to determine the level of environmental impact of the activity. If prior consultation is not demonstrated, then DMITRE will conduct a broader consultation on the draft documents to ensure stakeholders including landholders and other government departments have been provided with opportunities to raise any issues of concern they may have with the activities as described or the level or accuracy of information provided, prior to SEO approval and well before the commencement of regulated activities.

The significance assessment is conducted based on the information provided in the EIR and in accordance with publicly documented criteria to assess the level of certainty in the predicted impacts, their potential consequences related to the proposed activities and the degree to which these consequences can be managed. The environmental significance criteria include assessment of the level of stakeholder concern. In cases where the level of stakeholder consultation is not demonstrated or the EIR documents high levels of stakeholder concern then this may indicate deficiencies in stakeholder consultation during the development of the EIR and draft SEO. Where DMITRE's assessment identifies such a deficiency, the determined level of environmental significance may be greater and likely to trigger more extensive stakeholder consultation by DMITRE. This ensures relevant stakeholders are provided with appropriate time for opinions to be considered and represented equitably in advance of SEO and subsequent activity approvals.

The combination of the outcomes of the significance assessment criteria lead to the determination of an overall level of environmental impact of the activity as low, medium or high. The level of environmental impact that is assigned to a particular activity in turn determines the consultation that DMITRE undertakes, both on the level assigned, and the content of the EIR and draft SEO documents. These consultation arrangements are outlined within the PGE Act, and within administrative arrangements between DMITRE and its co-regulatory agencies, which are all available on the DMITRE website [7].

Regardless of the determined level of environmental impact, all SEOs and associated EIRs are public documents and can be found on the DMITRE website [8] within the Activity Reports section of the Environmental Register.

6. Activity notification and application for approval

The grant of PGE Act petroleum exploration, retention, production and pipeline licences does not provide an automatic entitlement to land access for regulated upstream petroleum operations.

Once an SEO is approved, a licensee can apply for approval to undertake a specific activity that is described within the relevant EIR and SEO. With the activity approval application the licensee provides DMITRE with an Activity Notification (Regulation 20 of the PGE Act) which contains detailed activity information including:

- an environmental assessment of the activity against the relevant SEO, including assessment as to whether the activity may have potential significant impacts on Matters of National Environmental Significance (MNES)
- landowner information (including copies of notices of entry sent to landowners)
- an assessment of the fitness for purpose of the licensee management systems and any facilities or equipment to be used
- work area clearance details and report
- risk assessment documentation
- any further information or material as required by DMITRE to ensure that the department has comprehensive information on the proposed activities.

Where MNES are identified, then referral to the Commonwealth Minister for Environment will be made by the licensee or the Department, for assessment and a decision as to whether the activity requires approval under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) [9]

Licensees can be classified as carrying out activities requiring high or low level official surveillance. The level of official surveillance determines the information that must be provided in the notification, the level of scrutiny that DMITRE applies during review of the notification, and the period of notice prior to the proposed commencement of activities. The PGE Act outlines operator assessment factors (Regulation 16 of the PGE Act) that consider the licensee's policies, procedures, management systems and track record to classify the licensee's level of official surveillance.

7. Notice of entry

Mutual trust for compatible, sustainable land access for upstream petroleum operations are traditionally indemnified with formal land access agreements struck between licensees, potentially affected people and enterprises. To provide impetus for fair and sustainable land access for petroleum, geothermal energy and gas storage operation in the State, the PGE Act was amended in 2009 to expand the 'owner of land' definition to cover all persons who may be directly affected by regulated activities, entitling them to notices of entry and compensation. This amendment has proved to be a driver for mutual respect. With this incremental legislated requirement, owners of land are provided with opportunities to raise concerns prior to the commencement of regulated activities.

Landowners are provided with information on the nature of the activities to be carried out including any anticipated events and the management of their consequences to minimise risks

to an acceptable level, to enable the landowner to make informed decisions on whether this would have an impact on the land.

Landowners are entitled to object to the licensees proposed entry by giving notice to the licensee within 14 days of the licensee notice of proposed entry and the activity cannot be undertaken until the dispute is resolved. The licensee and the landowner should attempt to reach an agreement of terms under which the licensee may enter the land, or if the risks of the activity to the landowner are too high the licensee may choose to modify the activity and re-issue the Activity Notification. Landowners may also raise any issues or concerns associated with the conduct of activities with DMITRE. In rare cases where the licensee and the landowner cannot resolve the dispute, then the Minister may attempt to mediate between the parties or either party may apply to the Warden's court for resolution. To date, disputed Notices of Entry have been resolved through satisfactory negotiation and have not reached the Warden's Court.

Also, under the PGE Act, owners of land are entitled to appropriate compensation from petroleum licensees for any losses, deprivation or reasonable costs sustained during both the process of negotiating land access and for the full period of land access, right through to the decommissioning of any facilities.

8. Compliance and enforcement

DMITRE continuously monitors licensee performance and compliance with the PGE Act. South Australia's approach to provide fair, predictable and trustworthy regulation has been described by Malavazos [10] and entails a publicly available compliance policy [11] which is available on the DMITRE website. South Australia's compliance policy is centred on the prevention of harmful incidents, however depending on the severity of an incident may culminate in prosecution and licence cancellation when warranted. The compliance policy is summarised as a compliance pyramid as shown below in Figure 4.

DMITRE prepares a PGE Act Annual Compliance Report for the purpose of outlining:

- The compliance monitoring and surveillance activities carried out by DMITRE during each year for activities regulated under the PGE Act;
- Providing an overview of the regulatory performance of the petroleum and geothermal industries in accordance with the requirements of the PGE Act;
- All serious incidents that may have occurred from the previous year; and
- Persuasive, compulsive and punitive enforcement actions that may have been taken during the year (as indicated in Figure 4)

DMITRE's Petroleum and Geothermal Energy Act Compliance Report [12] and Company Annual Reports [13] which report on activities undertaken within each licence area are all publicly available through DMITRE's website.

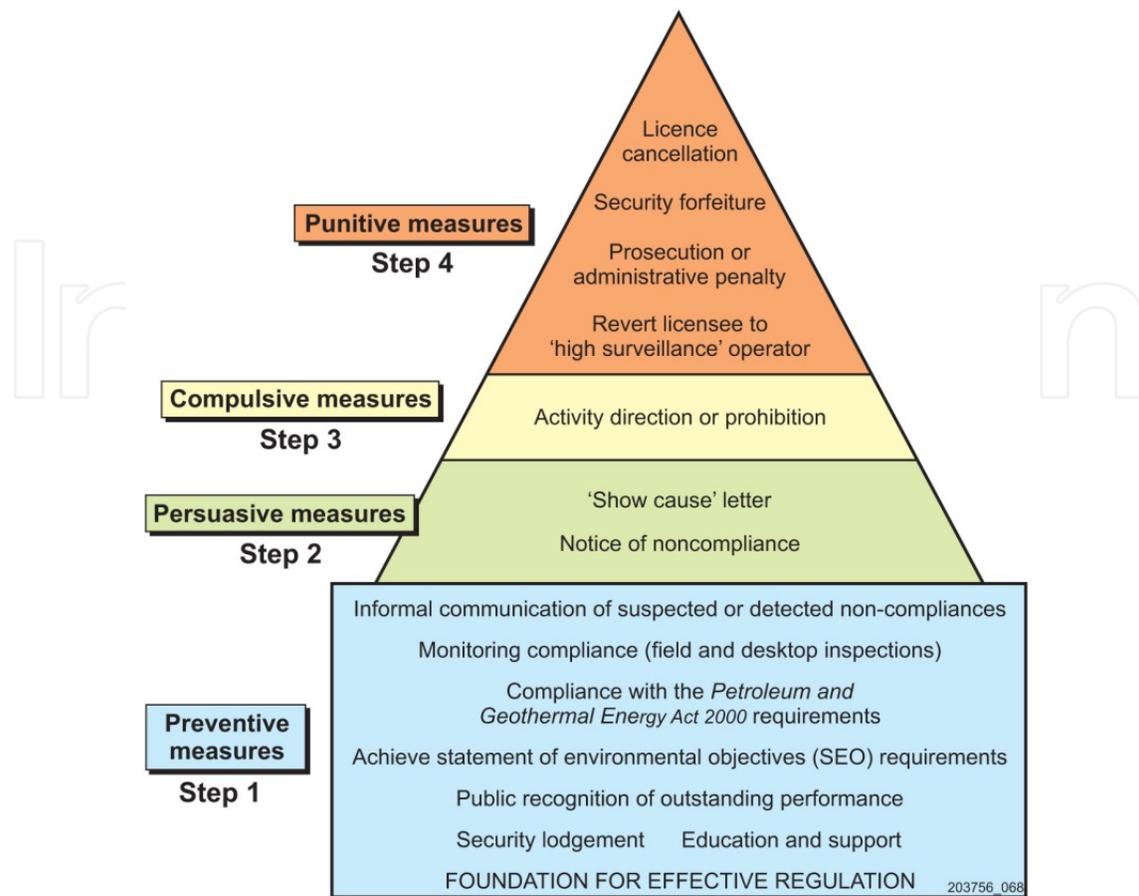


Figure 4. South Australia's compliance enforcement policy under the PGE Act.

As well as information provided through the Activity Notifications, DMITRE regularly meets with licensees to discuss their activities and compliance, and conducts ongoing monitoring and surveillance through both field and desktop studies.

9. Conclusions

Salient findings from the Roadmap [2] and key aspects of South Australia's current regulation of unconventional gas development, including the regulation of hydraulic fracture stimulation, are summarised below.

1. Trusted land access is the most valuable lead factor and outcome.
2. Operators and regulators must act early to effectively engage and inform stakeholders so they can make informed decisions on activities. This engagement is best initiated well ahead of land access. South Australia's regulatory framework drives operators to explain their planned activities and any potential risks, seek feedback on areas of interest or concern for the community, and establish relationships and terms for land access with stakeholders well before applying for activity approval from regulators.

3. Regulation for compatible, multiple use of land in Australia is undertaken with both risks and net benefits in mind. Considerable net benefits flow from community ownership of subsurface resources when development effectively manages risks to social, natural and economic environments.
4. Operators and regulators should adhere to the golden rules for the golden age of gas, as published by the International Energy Agency [14]– which are:
 - Measure, disclose, engage;
 - Watch where you drill;
 - Isolate wells – protect against leaks;
 - Treat water responsibly;
 - Eliminate venting and minimise flaring;
 - Think big; and
 - Consistent high environmental performance
5. International standards [15] for unconventional gas resource and reserve definitions should be adopted.
6. Effective, trusted regulation and attractive investment settings are the most effective inputs from governments to beget safe, secure, and competitively priced gas for domestic and international gas markets for decades to come.
7. Regulators must have relevant and up-to-date capabilities (competence and capacity) to be trusted to act in the interests of the public in protecting natural, social and economic environments in relation to the full-cycle of mineral and energy resource projects, including unconventional gas operations.
8. New energy development technologies will necessitate evolutionary improvement to regulatory frameworks, and best practice regulation will continually evolve
9. A one-stop-shop (lead agency) approach to regulation enables co-regulators to do their jobs in parallel, rather than in series. This fosters efficiency without reducing stringent standards for ecologic, social, heritage and economic outcomes.
10. Welcomed investment in the development of unconventional gas will effectively reduce risks to as low as reasonably practical while simultaneously meeting community expectations for net outcomes. This will be achieved with, amongst other actions, astute investment in economic unconventional plays,
11. The key ingredients of best practice regulation are frameworks that: elicit community trust and investor confidence; provide certainty; entail robust public consultation processes; are transparent; enable flexibility; are open to amendment; are efficient; are practical; and focus on outcomes. This amounts to an overall check-list for best practice co-regulation.

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References

- [1] Petroleum and Geothermal Energy Act (2000). South Australia <http://www.legislation.sa.gov.au/LZ/C/A/PETROLEUM%20AND%20GEOTHERMAL%20ENERGY%20ACT%202000/CURRENT/2000.60.UN.PDF>
- [2] Department for Manufacturing, Innovation, Trade, Resources and Energy. Roadmap for Unconventional Gas Projects in South Australia; December (2012). http://www.petroleum.dmitre.sa.gov.au/SA_Unconventional_Gas_roadmap
- [3] Goldstein, B. A, Alexander, E, Cockshell, D, Malavazos, M, & Zabrowarny, J. The Virtuous Life-Cycle for Exploration and Production (E&P): Lead and Lag Factors. APPEA Journal; (2007). , 47
- [4] Environmental Protection Act (1993). South Australia <http://www.legislation.sa.gov.au/LZ/C/A/ENVIRONMENT%20PROTECTION%20ACT%201993/CURRENT/1993.76.UN.PDF>
- [5] Malavazos, M. A Model for Environmental and Health and Safety Regulation for the Mining and Upstream Petroleum Industries. Masters thesis. Flinders University South Australia; (1998).
- [6] Productivity Commission Research Report- Review of Regulatory Burden on the Upstream Petroleum (Oil and Gas) Sector; (2009). www.pc.gov.au/__data/assets/pdf_file/0011/87923/upstream-petroleum.pdf

- [7] Department for Manufacturing, Innovation, Trade, Resources and Energy. Petroleum: Administrative Arrangements. http://www.petroleum.dmitre.sa.gov.au/environment/regulation/admin_arrangements
- [8] Department for Manufacturing, Innovation, Trade, Resources and Energy. Petroleum: SEO, EIR and ESA Reports. http://www.pir.sa.gov.au/petroleum/environment/register/seo,_eir_and_esa_reports
- [9] Department of Sustainability, Environment, Water, Population and Communities. Environmental Assessments. <http://www.environment.gov.au/epbc/assessments/>
- [10] Malavazos, M. The South Australian Petroleum Act 2000- principles and philosophy of best practice regulation. MESA Journal April (2001). , 21
- [11] Department for Manufacturing, Innovation, Trade, Resources and Energy. Petroleum and Geothermal Energy Act Compliance Policy; (2012). <https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/RB201000013.pdf>
- [12] Department for Manufacturing, Innovation, Trade, Resources and Energy. Petroleum: Petroleum and Geothermal Energy Act Annual Compliance Reporting. http://www.pir.sa.gov.au/petroleum/legislation/compliance/petroleum_act_annual_compliance_report
- [13] Department for Manufacturing, Innovation, Trade, Resources and Energy. Petroleum: Annual Reports. www.pir.sa.gov.au/petroleum/legislation/company_annual_reports
- [14] International Energy Agency Golden Rules for a Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas; (2012). www.worldenergyoutlook.org/media/weowebbsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf
- [15] Society of Petroleum Engineers (SPE) Petroleum Resources Management System; (2007).
- [16] DMITRE Roadmap for Unconventional Gas Projects in South Australia, Appendix 1; (2012). http://www.misa.net.au/__data/assets/pdf_file/0009/178344/Appendix_1_Rpundtable_Members.pdf