Inquiry into unconventional gas fracking

Submission from the South Australian Government

January 2015
Inquiry into unconventional gas (fracking): submission from the South Australian Government

Energy Resources Division
Department of State Development

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Introduction

This submission to the South Australian Parliament’s Natural Resource Committee (NRC) inquiry has been prepared by the Department of State Development with input from the Department of Environment, Water and Natural Resources, the Environment Protection Authority, Primary Industries and Regions SA, SA Health and SafeWork SA. These departments have a key regulatory role in managing the potential impacts from fracture stimulation (commonly referred to as “fracking”) activities.

Fracture stimulation has been safely used in both conventional and unconventional wells in South Australia’s Cooper Basin since 1969. The industry has been co-regulated under legislation administered by these departments who have considerable experience in assessing and regulating all activities in the upstream petroleum industry, including fracture stimulation, conducted by the petroleum industry in the State. Up to end of August 2014, 716 wells have been fracture stimulated in the South Australian portion of the Cooper Basin with no evidence of adverse impacts on aquifers within the Great Artesian Basin and other shallower aquifers.

In the South East of South Australia there has been no fracture stimulation to date, nor has there been any proposal to government for fracture stimulation in this region of the State. When a proposal is made, the process pursuant to the Petroleum and Geothermal Energy Act 2000 (PGE Act) will be followed to demonstrate how all significant risks will be avoided (including those identified through public consultation required under the PGE Act) and how community concerns will be effectively managed. Only after the due process of the PGE Act is complete (including public consultation and considering all input from co-regulators) will a determination be made to preclude or allow leading practice fracture stimulation to be undertaken in the South East.

Potential risks and impacts

This document has been prepared to outline the potential risks and associated, potential environmental impacts (additional to conventional well drilling and testing) that will be fully assessed under the PGE Act prior to fracture stimulation activities being permitted in the South East, should a proposal for fracture stimulation be submitted by a PGE Act licensee.

To date in the State of South Australia, because regulations require, and industry deploys leading practice risk control measures, potential residual risks of fracture stimulation have been determined to be low risks in relation to the necessary protection of social, natural and economic environments.

This finding will always be locally assessed for credibility in relation to local circumstances as a matter of due process in South Australia, pursuant to the PGE Act.

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1 The PGE Act and its associated Regulations can be readily accessed through the South Australian legislation website: www.legislation.sa.gov.au
Pending the assessment of potential risks to local (potentially affected) social, natural and economic environments in the South East of South Australia – no fracture stimulation operations are permitted in the South East of South Australia.

Experience in the fracture stimulation of more than 700 wells in the Cooper Basin in South Australia has enabled a clear general understanding of potential residual risks associated with fracture stimulation. A non-inclusive list of potentially affected social, natural and economic environmental factors follows and is detailed in the proceeding sections of this submission:

- impacts on water resources;
- impacts on soil;
- impacts on native vegetation and native fauna;
- impacts on potentially affected enterprises;
- impacts on landscape and heritage features;
- impacts on air; and
- impacts on the health and wellbeing (including traffic and noise) of potentially affected people and enterprises; and

The Environmental Impact Reports (EIRs) and approved Statement of Environmental Objectives (SEOs) that describe the potentially significant risks associated with ongoing oil and gas operations in the State are available at the following web address:


The EIR, approved SEO and approved State Government Environmental Impact Classification (Significance Test) for fracture stimulation in the Cooper Basin in South Australia provide a guide to the assessment and management controls required to reduce the above-listed risks to acceptable residual risks for fracture stimulation in the Cooper Basin. These EIR and SEO documents were the subject of public consultation and are publicly available at the following web addresses:


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2 A Health SA’s Health Impact Assessment will be a part of developing an Environmental Impact Report (EIR) and Statement of Environmental Objectives (SEO) for fracture stimulation in the South East of South Australia.
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In addition to the engagement undertaken for activity-specific and area-specific oil and gas operations, as required by the PGE Act (EIRs, SEOs, notices of entry and similar processes required by the PGE Act), the State Government has and will continue to consult with, and provide objective, balanced information to the public via:

- An open forum created in 2010 to inform industry strategies and government policies to underpin optimum life-cycle planning (including public acceptance) for the deployment of capital, technologies and infrastructure for projects focused on natural gas contained in unconventional reservoirs – the Roundtable Unconventional Gas Projects in South Australia. This forum was renamed the Roundtable for Oil and Gas Projects in South Australia in 2014 to cover all aspects of the oil and gas industry in the State of South Australia. This Roundtable currently has more than 620 members from companies, State, Territory and Federal government agencies, peak representative bodies for environmental protection, peak representative bodies for industries, research organisations, and individuals;

- The above-described Roundtable’s Working Groups that cover: (#1) skills and geo-engineering research; (#2) transport and infrastructure; (#3) water resources; (#4) inter-jurisdictional cooperation to create efficient and effective regulations for wharf to wellhead corridors; (#5) the measurement and monitoring of greenhouse gas emissions; (#6) a suppliers’ forum (formed in 2014) ; and (#7) a forum to cover the use of compressed and liquefied natural gas for transport and heavy equipment (that is forming in early 2015);

- Research undertaken under the auspices of the above-described Working Groups. One topical example will be the independent research that has just been commissioned so the National Centre for Groundwater Research and Training can undertake a review of international publications and publish a paper (tentatively) to be named, “The Impact of Unconventional Gas on Water Resources: Replacing Myths with Scientific Evidence”. Plans are in place for this report to be concluded in 2015;

This research is funded through a State Government grant that is, in turn, offset, by PGE Act licence fees, in a way that avoids editorial influence by industry on the contents of publication that will eventuate;


- The publication and web-posting of reliable answers to frequently asked questions (FAQs) in relation to oil and gas projects including fracture stimulation operations. Download from: http://www.pir.sa.gov.au/__data/assets/pdf_file/0003/218109/FAQ_South_East_Unconventional_Gas_and_Oil.pdf;

• EIR, SEO and notice-of-entry consultation to inform potentially affected people and enterprises as to residual (controlled) risks relating to oil and gas projects including fracture stimulation operations. The process of consultation is described in some detail in the proceeding text;

• Numerous presentations at conference, to local governments, to Parliamentarians and to non-government organisations. Presentations in schools will become a greater focus in 2015; and

• Hundreds of correspondences in relation to oil and gas projects including fracture stimulation operations that are in reply to constituents’ concerns and questions as posed to members of South Australia’s State Parliament and government agencies.

The above-listed initiatives were instigated and are actioned by knowledgeable State Government regulators and policy makers earlier (and arguably better) than anywhere else in Australia. The objective in all of these efforts in the past and in future will be to communicate effectively. The overall targeted outcome will be a well-formed public. One particular targeted outcome of the processes required under the PGE Act is that potentially affected people and enterprises are well informed as to the realistic potential risks and risk management associated with oil and gas projects in the State – including projects that may include fracture stimulation operations.

This submission does not specifically address the potential risks and potential impacts commonly associated with conventional oil and gas well drilling in the South East, which are well documented in the existing approved Statement of Environmental Objectives (SEO) for the area. The process to assess potential environmental risks (which are broad in scope and include public health) of these activities under the PGE Act is comprehensive and science-based. A full detailed assessment of all potential risks and potential impacts associated with potential fracture stimulation activities in the South East will be detailed as a part of due process under the PGE Act. That detailed assessment will account for the specific location and depth of proposed fracture stimulation, and will be documented for public consultation in the form of an Environmental Impact Report (EIR) under the PGE Act, should fracture stimulation be proposed in the South East in the future.

Risk assessment as required under the PGE Act is a rigorous process that considers both the probability of an adverse impact event occurring and the consequence of that event (which may be trivial or significant). Possible impact events consider the potential source (e.g. contaminant chemicals used in fracture stimulation), the pathway or mechanism (e.g. surface spillage) that may lead to impact on a receptor (e.g. users of the near surface aquifer, etc.). The impacts that are addressed through regulatory processes focus on those that may have a significant consequence (i.e. those that may impact other users of natural resources, or ecological

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5 Refer to AS/NZS standard 4360 “Risk Management” of an outline of this process.
communities) and those that require regulatory control (i.e. those that require the proponent to put in place an engineered control mechanism). Where there is significant uncertainty in a particular risk (either due to significant uncertainty in the probability or consequence), a precautionary approach applies. Regulatory standards are and will be set based on evidentiary science and necessary engineering capabilities that are appropriately proportionate to the potential risk, and will be reviewed with experience. The effectiveness of mitigation strategies needs be demonstrated for widespread deployment. Trials of prospective, evolutionary risk mitigation are restricted to locations where receptors to risk are minimal while measurement and monitoring are deployed to establish the efficacy of innovative risk management processes and technologies.

It is especially worthwhile for the Committee to note that some controlled and uncontrolled risks perceived by a section of the public may be of such low probability or low consequence as to be not a credible significant risk based on known science and/or engineering data – either controlled or uncontrolled in the context of leading practice risk management processes and technologies.

Deep unconventional gas vs. coal seam gas

It is important to understand that the operations to develop natural gas from unconventional shallow coal seam gas (CSG) reservoirs in Queensland and New South Wales (which have stirred community concern in the South East of South Australia) are different from the operations used to develop natural gas in deeply buried unconventional shale, siltstone, and tight (low permeability) sandstone reservoirs in South Australia. In South Australia (including the South East), there are currently no industry project proposals for developing shallow CSG. Shallow CSG is very different to the deep unconventional gas resources that have been targeted in the South East of South Australia. In general, shallow CSG resources are prone to be near shallow, multiple-use water resources at depths less than 1,000 metres below surface, with only 5-10% of the wells requiring fracture stimulation. In general, shallow CSG reservoirs need first to be dewatered before water-free gas will flow from the coal seam to enable commercial gas production. Dewatering entails a range of volumes of ground water produced that needs be managed in environmentally sustainable ways. The management of water produced from CSG reservoirs can result in fresh water supplies otherwise unavailable for multiple purposes, or safe injection into aquifers, or evaporation from fenced-off and lined ponds. All forms of managing water production from coal seams are required to protect air, soil and groundwater from undesirable contamination. Deep gas trapped in unconventional reservoirs in South Australia are generally at depths greater than 2,500 metres below surface and conceptually require fracture stimulation to produce natural gas at commercial flow rates of gas. Restricting fracture stimulation to gas-saturated unconventional reservoirs can be expected to result in little co-production (with gas) of associated (deep-sourced) formation water. The

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6 DSD-ERD offers the committee (and the Parliament more generally) a review of modern, professional risk management as deployed by co-regulators locally, nationally and internationally as these concepts enable innovation and mitigate uncertainty as to how practical and reliable regulation works.
shallow potable aquifers of the Gambier Limestone and Dilwyn Formation in the South East of South Australia are generally at depths no more than 500 metres below surface and hence, well above and segregated from deeper (>2,500 metres) formations that that may be targeted for natural gas in unconventional reservoirs.

What are unconventional gas and fracture stimulation (fracking)?

This submission:

- addresses the key issues listed under the terms of reference to the inquiry; and
- also clarifies that natural gas in unconventional reservoirs (sometimes inexplicitly called “unconventional gas”\(^7\)) and fracture stimulation are not the same thing.

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\(^7\) There is nothing unconventional about the production and use of natural gas (that is largely methane gas). Indeed, the term 'unconventional gas' can be misleading. It is more appropriate to describe shale gas, tight gas and coal seam gas as natural gas in relatively low permeability reservoirs that include shales, siltstones, sandstones, carbonates and coals.
Natural gas in unconventional reservoirs (or unconventional gas resources) is a mixture of gaseous hydrocarbons (methane, ethane and other naturally occurring compounds) that are regionally pervasive, contained within underground formations such as coal, shale, siltstone or sandstone of low natural permeability (e.g. tight gas sands) as shown in Figure 1 (on the previous page).

Coals and shales are sedimentary rocks that are largely comprised of inorganic clay- and silt-sized particles along with varying amounts of solid organic matter (largely plant remains). Coals and shales can also (commonly) be petroleum source rocks in which natural processes convert fossil solid organic matter to oil and/or gas during exposure to heat energy at depth over time during the burial of clay, silt and organic matter in the geological past. The generation of oil and gas in micro-pore spaces within evermore compacted shales (with depth of burial) can naturally increase pore-pressures to levels when natural micro-fractures evolve within the shale, and these micro-fractures provide pathways for naturally generated oil and gas to be expelled from source rock shales to non-source rocks, and naturally, buoyantly migrate to surface or be trapped in conventional and unconventional subsurface oil and gas accumulations.

The origin of natural gas in coals, the storage of natural gas in coals and the expulsion and extraction of natural gas from coals is, in some geologic settings, different to the above-described process for the generation of oil and gas in, and expulsion / extraction from shales. Natural gas formed in coals may be the result of:

- exposure to heat energy at thousands of metres of depth (e.g. thermogenic, as for shale source rocks); and

- biogenic processes related to the activity of microbes (bacteria) in low-oxygen (anaerobic) conditions within coals (and other rocks rich in organic fossil remains) at relatively modest subsurface depths and temperatures

Natural gas formed in coals by either thermogenic or biogenic processes tends to be adsorbed to the surfaces of coal and held in place by the fluid pressure created by both water and generated petroleum under the weight of rock and sediment overburden.

Where coals have a considerable water content - the expulsion or extraction of natural gas from coals requires a reduction of fluid pressure by the removal of the contained water. The removal of the water can be natural, as a part of the burial history of the coal, or induced by producing water from the coals via a production wellbore. A water well that drilled through a natural gas-bearing coal (where the natural gas is biogenic or thermogenic) can unload water from the coal and result in gas production into the water well and then into any water in pressure communication with the water well. As detailed herein, poorly constructed petroleum wells have also been a source of natural gas in water resources. The risk of any drilled wells flowing natural gas where it is unwanted can be effectively mitigated with proper well construction, as is standard (and required) practice for petroleum wells in South Australia.
The natural gas within dry coals (that contain little water) is expelled and extracted in ways similar to that of shales\(^8\).

Production of natural gas at economic rates of flow from unconventional reservoirs usually requires the application of additional extraction technologies. Examples of these extraction technologies include dewatering of coal seams for CSG (as described above), fracture stimulation and/or horizontal drilling for gas in shale, siltstones and tight sandstones. Some coals are also fracture stimulated to increase flow rates – but fracture stimulation is only applied to a minority of shallow coal seam gas wells.

Production of natural gas and/or oil from conventional reservoirs does not require – for example – fracture stimulation to be produced at economic rates, but fracture stimulation is sometimes used to improve conventional reservoir properties to accelerate gas and/or oil production. The acceleration of petroleum production can improve the time-value economics of conventional petroleum production.

“Fracture stimulation” or “hydraulic fracturing” colloquially known as “fracking” in media reports. Fracture stimulation is a technology used to induce fractures and fissures in rock, creating higher permeability pathways from oil and/or gas filled reservoirs to cased and cemented wellbores. The technique involves: (1) the construction of wells to ensure naturally occurring oil and gas flows from petroleum-saturated reservoirs into a cased and cemented wellbore; (2) down-hole equipment is set so that flow is constrained within a section of the cased borehole; (3) using specialized down-hole perforation guns, the cemented steel casing is perforated across only the petroleum saturated zone that is targeted for production of oil and/or gas; (4) a mixture of mainly water mixed with sand (99.5% volume) and chemicals (0.5% volume) is injected at high pressure into the perforations made in the cased wellbore to create small fractures (typically less than 1-2 mm) within the otherwise lower permeability rock near the perforated wellbore (refer figure 2).

Hydraulically induced fractures are located to avoid intersecting geologic faults that might enable flow from, or into levels other than those targeted for production.

Research into petroleum field development led by Durham University in the UK\(^9\) indicates that there is a less than 1 per cent chance of a stimulated fracture propagating upwards for more than 350 m, and that the maximum recorded distance of such a stimulated fracture is less than 600 m. These figures have been confirmed by actual data from the Cooper Basin in South Australia. Fracture stimulation design will dictate the actual vertical and horizontal extent of fracture propagation in the specific case, dependent on the rock characteristics at the specific location, but will always be within these maximum possible engineering limits.

As stated above, this technique (fracture stimulation) can be used to improve the productivity for both conventional and unconventional gas reservoirs. The fracture stimulation fluid (largely

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\(^8\) For some additional relevant details – see: [http://www.water-research.net/index.php/methane](http://www.water-research.net/index.php/methane)

water) pumped under high pressure through the perforations into the target reservoir zone is designed to create fractures and enlarge natural fractures in the rock.

Guar gum or similar substances that modify the viscosity (thickness) of water and other chemical additives are then added in low concentration to enable proppants, typically sand or ceramic beads, to be carried from the surface to the underground zone to ‘prop’ the newly created fractures open and prevent them from closing up after pressure is released. This allows gas otherwise trapped in the unconventional reservoir to flow through the induced fracture system to the production well.

When the well is flowed back to the surface, after the stimulation is completed, some of the injected stimulation fluid is recovered and some remains trapped in the rocks below the ground. The fracture stimulation fluid that is flowed back is contained in fenced-in or otherwise isolated lined ponds for evaporation or collected in the gathering system for appropriate disposal at an approved offsite location. The residual fracture stimulation fluid that remains in the unconventional reservoir is without permeability pathways from the rocks targeted for fracture stimulation to other strata.

The shallow potable aquifers that may be passed through when the well is drilled are isolated from the fractured reservoir and the fracture stimulation fluids by the cemented steel casing which lines the well. The casing provides a mechanical barrier between the inside of the well and the geological formations. The cement provides zonal isolation behind the casing between geological formations and also protects the casing. Geo-mechanical modelling of the stress contrast between various underground strata is used to assist in design of fracture stimulation treatments.

Fracture stimulations are designed to fracture only the targeted petroleum-saturated reservoir formations. Techniques such as micro-seismic are used to monitor fracture propagation during the stimulation process to confirm the fractures generated are as per the design.
Figure 2: Fracture stimulation of shale or tight gas reservoir.
Previous and proposed petroleum drilling and production activities in the South East

The potential unconventional gas reservoirs in the South East of South Australia are the shales, siltstones and low permeability sandstones of Lower Cretaceous (age) found in the Otway Basin.

*Figure 3: Map of petroleum activity and petroleum sub-basins in the South East*
Figure 3 locates petroleum wells and key geological trends, including the location and names of key sub-basins in the Otway Basin in the South East of South Australia. The Otway Basin in South East South Australia has been actively explored since the 1890s, with the first deep exploration well (Robe 1) being drilled in 1915.

Historical petroleum exploration and production drilling activities in the South East of South are summarized below.

<table>
<thead>
<tr>
<th>Years in which drilling commenced</th>
<th>Number of wells drilled in year</th>
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<tbody>
<tr>
<td>1910 to 1919</td>
<td>2</td>
</tr>
<tr>
<td>1920 to 1929</td>
<td>5</td>
</tr>
<tr>
<td>1930 to 1939</td>
<td>1</td>
</tr>
<tr>
<td>1960 to 1969</td>
<td>28</td>
</tr>
<tr>
<td>1970 to 1979</td>
<td>12</td>
</tr>
<tr>
<td>1980 to 1989</td>
<td>20</td>
</tr>
<tr>
<td>1990 to 1999</td>
<td>37</td>
</tr>
<tr>
<td>2000 to present</td>
<td>12</td>
</tr>
</tbody>
</table>

Commercial carbon dioxide (CO$_2$) was discovered in Caroline 1 in 1968 and the Caroline Carbon Dioxide Purification Plant located south east of Mount Gambier is still in operation. The liquid CO$_2$ is transported by road tanker to supply soft drink, firefighting and medical industry markets in Melbourne and Adelaide.

It was not until 1987 that the first commercial gas discovery was made at the Katnook Gas Field, followed by discovery of the Ladbroke Grove Gas Field in 1989. In 2007 the appraisal of the Jacaranda Ridge Gas Field significantly upgraded the northern portion of the Penola Trough for potential light petroleum liquids-rich gas (condensate) discoveries. The lack of early success may be attributed to poor quality seismic data prior to the early 1980s, and a poor understanding of the complex geology in the Robe and Penola Troughs (that are located in figure 3). Good-quality modern seismic coverage now exists over the offshore and most of the onshore parts of the basin and the geology are better understood.

Under the PGE Act, many petroleum exploration and production activities have been approved and undertaken safely in the South East including geophysical exploration activities, drilling operations, gas pipelines, and the Katnook Gas Processing Facility.

No fracture stimulation activities have been undertaken or proposed in the South East of South Australia to date.

Successive South Australian State Governments and their co-regulatory agencies have concluded that these historical activities have been successfully undertaken with no significant impact on the environment or other land users.

An example of contemporaneous compatibility of multiple land use – including gas exploration, development and production is evidenced with the Katnook Gas Field and the Ladbroke Grove Gas Field. Indeed, seismic, drilling, gas processing, production, and pipeline activities have been relatively frequent operations in the South East, and despite these activities being located in the highly valued Coonawarra wine growing region of the South East, the landowners concerned have been demonstrably able to continue their various agricultural activities in
compatible, contemporaneous coexistence with the petroleum activities. Indeed, outcomes have been demonstrably safe and without significant, perceptible, associated, negative impacts on natural environments, enterprises or the health and safety of people.

The most recent exploration drilling undertaken in the South East is that by Beach Energy near Penola. Beach Energy recently drilled two deep exploration wells, (Jolly 1 and Bungaloo 1), both of which sought to confirm whether or not petroleum liquids rich gas in unconventional reservoirs are present in the lower Sawpit Shale and Casterton Formation between 2,800 and 3,600 metres depth below ground level. Operations in the drilling of Jolly 1 and Bungaloo 1 wells were managed in accordance with all regulations (including the approved SEO referred to earlier). There were no reportable or serious incidents recorded as defined by the PGE Act during operations of these two exploration wells.

In accord with the probity of the State’s regulatory framework for all petroleum operations anywhere in South Australia, post-drill regulatory compliance audits for these two Beach Energy exploration wells will be continued by DSD in 2015 and beyond, as appropriate.

Beach Energy’s recent exploration drilling comprised conventional oil and gas drilling operations which are routine in South Australia, with thousands of such wells drilled in the State, including over 110 petroleum wells already drilled in the South East of South Australia over the last century. Beach Energy’s Jolly 1 is the deepest well in the South Australian Otway Basin and was drilled to 4026 metres.

The potential risks relating to the exploration well operations stage of Beach Energy’s Otway Basin program have been adequately addressed through the environmental assessment and approval process under the Petroleum and Geothermal Energy Act 2000 (the PGE Act) culminating in the publicly disclosed Environmental Impact Report (EIR) and approved Statement of Environmental Objectives (SEO). No fracture stimulation has been approved nor has it been proposed by Beach Energy at this stage of the exploration program.

Beach Energy has concluded as a result of this drilling that the area now has both potential for gas in both unconventional and conventional reservoirs, with the future focus on gas in conventional reservoirs and within the footprint of existing gas fields. As a result, Beach Energy’s Managing Director Reg Nelson has said:

“As a priority, we will now focus our efforts on the conventional potential within the Penola Trough. A real advantage that Beach has in this region is that any future successful conventional wells could potentially be tied-in to the SEAGas pipeline through the infrastructure we own in the region, which includes the Katnook gas processing facility.”

10 Definitions for reportable and serious incidents for drilling and well operations the South East can be found in Table 2 of the SEO for Drilling, Completion and Initial Production Testing in the Otway Basin, South Australia: http://www.pir.sa.gov.au/__data/assets/pdf_file/0016/214054/A397B-Otway_Basin_Drilling_SEO-Rev2.pdf
Potential risks of groundwater contamination

The main potentially significant risks of contamination of aquifers associated with fracture stimulation that are additional to conventional drilling are:

1. Significant cross-flow of fracture stimulation fluids, oil and/or gas (including methane) or deep saline groundwater to shallow potable aquifers due to inadequate well construction;

2. Significant release of fracture stimulation fluids and chemicals to potable surface aquifers due to a spill or breach at the surface leading to downward leakage; and

3. Worker exposure to chemicals and silica used in the fracture stimulation process.

In general, these risks are similar to those of managing conventional drilling and production fluids, and are addressed in the existing approved EIR and SEO.

Overall, the risks of contamination of aquifers by fluids (whether they be drilling or fracture stimulation fluids) will predictably be very low, given the small volumes of chemicals used compared to the large volumes water present in the aquifer, and most importantly, the multiple engineered containment barriers between the chemicals and the aquifer that prevent any significant contamination from occurring.

There are perhaps unsubstantiated perceptions within parts of the public as to the potential risk of fractures propagating into aquifers utilized in the South East. As noted above, based on current technology and unequivocal geological data (including thousands of metres of sealing rock between these aquifers and the potential petroleum reservoir fracture stimulation targets), the risk of fracture propagation at depths below 2,500 metres leading to fracture stimulation fluids contaminating shallow aquifers is unrealistic.

The main sealing units are the Eumeralla Formation, Laira Formation and upper Sawpit Shale, which in total provide approximately 2000m separation (including natural impermeable barriers) from the aquifer units (refer figure 4). The maximum ever recorded height of fracture stimulation is less than 600m, as referenced earlier. The small volumes of chemical that remain in the fracture stimulated reservoirs cannot realistically migrate upwards to aquifers (used by people and industries) from the fracture stimulated intervals due to many overlying natural aquitards and low permeability rocks adjacent to, but unaffected by the fracture stimulation. Hence, the small volumes of chemicals pumped into, and not flowed back from fracture stimulated intervals are expected to remain in the fracture stimulated petroleum reservoirs indefinitely.
Chemicals used in fracture stimulation

Chemicals may be added to the water used for fracture stimulation for a variety of purposes, such as to:

- carry the proppant;
- reduce the friction between the water and the pipe or casing in the well;
- stop the growth of bacteria in the well and underground intervals;
- clean the well and increase permeability near the base of the well;
- prevent scaling and
- remove oxygen to prevent corrosion of the casing.

Water and sand make up around 97 to 99 per cent of the fracture stimulation fluid. Added chemicals make up about 1 to 3 per cent. Fracture stimulation fluid mixtures are designed to be compatible and toxicologically safe for use in the petroleum-saturated reservoirs that constitute
the fracture stimulation targets. Some commonly used chemical additives, and their uses, include:\(^{13}\):

- guar gum (a food thickening agent) used to create a gel that transports sand through the fracture;
- bactericides, such as sodium hypochlorite (pool chlorine) and sodium hydroxide (used to make soap), used to prevent bacterial growth that contaminates gas and restricts gas flow;
- ‘breakers’, such as ammonium persulfate (used in hair bleach), that dissolve hydraulic fracturing gels so those gels do not impede the flow of water and gas;
- surfactants, such as ethanol and (cleaning agent) orange oil, used to increase fluid recovery from the fracture by reducing surface tension; and
- acids and alkalis, such as acetic acid (vinegar) and sodium carbonate (washing soda) to control the acid balance of the fracture stimulation fluid.

Some hydraulic fracture stimulation fluids may also contain chemicals that are not commonly associated with domestic use but have common industrial uses (e.g. cyclohexylamine; ethylene diaminetetra acetic acid tetrasodium salt [EDTA]).

As stated above, chemicals used in fracture stimulation are highly diluted in practice and much of the fracture stimulation fluid is recovered during the treatment and flow-back processes. Table 1 (that follows on the next page) provides an additional non-exhaustive list of the common chemicals that are found in fracture stimulation fluids, along with their more familiar uses in households today.

A full list of fracture stimulation additives and their chemical constituents used in South Australia’s Cooper Basin are publicly available within EIRs on the DSD website\(^ {14}\).

Table 1 includes other common uses for the chemicals used in fracture stimulation fluids, but this should not be taken to mean that that all of these chemicals are perfectly safe if properly stored but handled in a concentrated form. A comprehensive on-site chemical safety management plan (addressing transport, storage, use and waste) is required to be approved by the regulators before any proposed fracture stimulation would be approved to prevent impacts to workers, the public and the environment. This would include consideration of all chemicals to be used and their potential cumulative toxicity, as for the use of potentially hazardous substances by any industry.


The CSIRO, the National Industrial Chemical Notification and Assessment Scheme (NICNAS) and the Commonwealth Department of Environment are undertaking a joint study\(^{15}\) into the health and environmental impacts of chemicals associated with Coal Seam Gas fracture stimulation activities. The main aim of this study is to identify which of all chemicals likely to be used in fracture stimulation activities (which would be similar to those used to improve the flow capacity of other types of unconventional reservoirs) have or have not had a toxicological and/or eco-toxicological assessment undertaken already, either in Australia or overseas.

Prior to any well operations being approved by government authorities, appropriate baseline studies are required in South Australia to be undertaken to determine the level of existing contaminants in the aquifers so that any contamination by the well operation can be detected.

Potable aquifers in the South East that must be protected

Groundwater in the South East is a highly valued resource as it is the only source for potable water supply (individual domestic bores and town water supply schemes operated by SA Water) for a population of 65,000, and is relied upon by agriculture (including stock drinking water) and industry. Industrial uses include wineries, timber processing, paper manufacture, and in the operation of farm dairies, sale yards, and abattoirs. Agricultural uses include irrigation of pastures, fruit (includes vineyards and orchards), crops (includes potatoes, seeds and hay), as well as use by forests. Additionally, groundwater in the SE is inherently linked to groundwater dependent ecosystems such as wetlands.

The Government invests considerable resources in protecting groundwater in the South East, via Water Allocation Plans, monitoring, and licensing and regulating of industries for activities that have the potential to cause pollution to groundwater.

The measurement and monitoring of precious water resources are standard practices for all industries (including the oil and gas industry) in the South Australia. The measurement and monitoring of water is undertaken to both prevent contamination and to determine the status of efforts to restore water quality in some locations. In this regard, it is worth noting that strategies have been deployed to prevent further, and restore pre-existing impacts on the shallow unconfined aquifers (Gambier Limestone) from legacy agricultural practices16.

The shallow aquifers (confined and unconfined aquifers) that are used for human, ecological and agricultural purposes in the South East are separated from the deep gas resources by thousands of metres of sealing rock, which has such low vertical permeability that it prevents even gas migration over millions of years.

Fracture stimulation fluids have a higher viscosity than natural gas, and hence are even less able to migrate through low permeability rock.

Without these sealing rocks (which comprise the shales of the Pember, Eumeralla, Laira and Upper Sawpit geological formations), there would be no significant conventional petroleum accumulations in the Lower Cretaceous (age) rocks in the South East, as oil and/or gas generated in, and naturally expelled from source rocks would have already have migrated naturally to the surface and be lost to the atmosphere.

Two aquifers that require protection in particular have distinct properties that result in different potential risks from fracture stimulation:

The Gambier Limestone is an unconfined aquifer. This means that it is improbable for any significant gas resources to accumulate within the aquifer, as it would naturally migrate to surface and then vent to the atmosphere. Potential contamination pathways to the Gambier

Limestone exist at the surface where a spill or breach may lead to downward leakage of contaminants; and

The Dilwyn Formation is a confined aquifer. Minor levels of naturally occurring methane gas are dissolved within this aquifer and produced during pumping of shallow water bores. Government sampling results from water bores in the region in 1993 showed that on average approximately 1% by volume of gas per volume of water samples (v/v), and of that 1% (v/v) gas was between 25% to 92% methane with the balance of that 1% (v/v) gas was comprised of nitrogen, oxygen and carbon dioxide. Analysis of the samples found that the majority of sampled methane was bacterially formed e.g. biogenic, formed through natural, modest temperature processes.

The key to preventing potential contamination of shallow, potable aquifers are good industry practices as deployed for all petroleum well construction targeting oil and/or gas in both conventional and unconventional reservoirs in South Australia. Just such practices are required by stringently enforced regulations in South Australia by ensuring:

- Wells are designed and constructed in accordance with relevant industry standards to meet pressure, temperature, operational stresses and loads;
- Aquifers are isolated behind multiple casing strings and a competent cement bond and placement is demonstrated;
- Monitoring programs are implemented (e.g. well logs, pressure measurements, casing integrity measurements and corrosion monitoring) to assess the condition of casing and potential for any cross-flow behind casing;
- Monitoring of existing bores in close proximity to assess changes in water quality;
- If cross-flow is detected, appropriate remediation is undertaken promptly;
- Isolation barriers are set in place in accordance with applicable standards for the decommissioning of petroleum wells to ensure that cross-flow does not occur;
- All fuel, oil and chemicals are stored and bunded in accordance with relevant standards; and
- Adequate spill response/contingency plan in place to ensure any appropriate remedial action is undertaken promptly.

Further information to the above-stated points can be found in specific EIR and SEO documents, publicly available on the DSD website, as referenced above. The potential risk of an uncontrolled flow from a petroleum well is globally well managed, and is a rare event worldwide.

The potential risk of an uncontrolled flow from petroleum wellbore relates to the potential loss of well integrity, where fluids and/or gases from within production tubing and/or layers of casing

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18 More efficient and effective technologies and methodologies are constantly being pursued by the upstream petroleum sector. “Edible” fracture stimulation fluids (Halliburton’s “CleanStim” fluid, which uses ingredients utilised in the food industry) and Halliburton’s self-healing cement (cements that can self-heal behind pipe to reduce the potential for cross-flow) are two such recent innovations.
are leaking due to some infrequent causation factor and, the cement around the well bore and between stings of casing (which is designed to ensure aquifers fluids cannot mix through the well) fails or is not placed correctly.

![Conceptual Well integrity design](http://www.appea.com.au/oil-gas-explained/production/drilling-and-well-construction/)

**Figure 5**: Conceptual Well integrity design. Petroleum wells have as many as eight layers of steel casing and cement that form a continuous, protective barrier between the well and the surrounding rock. The well design and program are reviewed, approved by drilling engineers, implemented and monitored by licence operators and separately, independently reviewed, approved, and monitored qualified and experienced experts within South Australia’s DSD-ERD.

Wells are designed to have multiple layers of steel casing and engineered cement that form a continuous barrier between the well and surrounding rock (refer figure 5). Casing and cement are pressure tested for leak-tightness prior to taking further steps in well construction. Cement integrity evaluation tools are used to assess the cement bond to confirm long term integrity of the well construction. This process, which is the subject of continuous innovation by industry, is heavily regulated by DSD-ERD and requires that operators adhere to the highest well design standards, including ongoing monitoring of the integrity of each barrier (casing strings) within the well bore. The requirements of DSD-ERD are consistent with and in many cases exceed globally recognised best industry practice.

Well integrity failures (leaks) are infrequent events. Nonetheless, regulations in South Australia require risk management to both avoid well integrity failures and the monitoring of petroleum wells to enable the detection of leaks within, or from wells at an early stage, before any

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20 Note that this is not conventional “cement” as used in the construction industry. Rather it is a product specially developed for the petroleum industry that is resistant to high temperatures, acids and has a very long life.
significant harm is done to surface or adjacent subsurface water resources, air, soil, people or enterprises.

Additionally, not all well integrity failure events pose even theoretical risks to water resources, air, soil, people or enterprises. Some infrequent instances of the failure of internal casing, or the failure of production tubing within other cemented casing, only results in leaks within the well e.g. the well remains under control, neither leaking into surrounding rocks, nor leaking at surface.

There are several potential factors that can cause such infrequent well integrity events. Unusual metal fatigue and/or corrosion may be a cause of well integrity failure. Poor coverage or placement of the cement within the annulus or annuli between various casing strings, and in some cases between the casing string and the formation that was intended to be isolated (refer figure 6) may also be the cause of infrequent well integrity events. As stated above – not every well integrity failure poses risks to water resources, air, soil, people or enterprises.

Figure 6: Potential well integrity failures (All of these are detectable and able to be remediated by appropriate use of technology)

In a study21 of over 200,000 wells in the United States the frequency and likelihood of casing failures is extremely low compared to other risks faced by society in general. This study should also be considered in the context that many of the 200,000 wells would have been completed in the past when the rigor of regulatory control would be well below modern standards. Standards for petroleum well construction in South Australia have and continue to be world’s leading practice.

21 October 2013: Environmental Risk Arising From Well Construction Failure: Difference Between Barrier and Well Failure, and Estimates of Failure Frequency Across Common Well Types, Locations and Well Age: SPE 166142, Table 8. p.13
The importance of well integrity as a barrier for containment is highlighted by one study\(^\text{22}\) that assessed water samples from drinking water bores overlying the Marcellus and Barnett Shales in the US. The data from that study rules out fracture stimulation and horizontal drilling as the source of fugitive natural gas in aquifers. There was no evidence of conduits to connect the deep shale formations to surface aquifers. Rather, most samples were found to be gas-rich from natural processes. There were nonetheless cases where fugitive natural gas from poorly constructed wells was the determined source of increased gas contamination (of aquifers) over time. Where fugitive gas contamination occurred, leakage was due to poor well integrity.

The South Australian regulatory process under the \textit{Petroleum and Geothermal Energy Act 2000} (PGE Act) requires fit-for-purpose monitoring. PGE Act licensees are required to demonstrate compliance with the regulations.

In terms of well integrity, to ensure protection of potable aquifers and all land users’ access to that water, background sampling and analysis of aquifers are required to be undertaken before drilling activities commence. These are requirements specified in relevant Statement of Environmental Objectives (SEO), a key regulatory instrument under the PGE Act.

Regular ongoing sampling is then undertaken at appropriate intervals to demonstrate that no contamination is occurring.

Furthermore, prior to the completion of the well, the SEO requires the licensee to demonstrate that cement integrity behind the casing is adequate and meets relevant industry requirements. This is most often achieved through the use of sonic cement bond log tools being run in the hole which measure the cement coverage behind the casing and more importantly the integrity of the cement bond.

### Potential impacts on landscape

As noted above, the exploration for, and production of natural gas in unconventional reservoirs in the South East does not include (nor is it expected to include) shallow coal seam gas (CSG) because no such shallow CSG resources are recognised as prospective for gas production in the South East.

Shallow CSG typically involves a large number of shallow wells drilled in a semi-grid like pattern and connected by gas gathering flow-lines, and hence may raise concerns by the community about difficulties created for surface logistics for pre-existing or future alternative land use – including agricultural land use (due to the high density of land disturbance due to extraction wells).

Fewer surface drilling locations and fewer gas gathering flow-lines are required to produce natural gas from high pressure, deep gas resources (as targeted in the South East), as compared to requirements to produce from low pressure, shallow CSG resources.

Also, multiple wells can be drilled from a single drilling pad into a deep natural gas resources, greatly reducing the surface footprint of production wells and associated gas gathering flow-lines and pipelines. It is expected that, if developed in the South East, the footprint for the development of natural gas in deep unconventional reservoirs would be similar to that previously used for production of natural gas from conventional reservoirs at Katnook.

The second important consideration regarding potential impacts on landscape is that any natural gas or oil exploration or production well is always only a temporary land use, as each well has a limited production life (perhaps of the order of 5-10 years) after which the land can be fully restored to pre-existing or future alternative land-use, including agricultural land use. As noted above, previous petroleum production activities at Katnook Gas Field and the Ladbroke Grove Gas Field have been conducted in compatible, contemporaneous co-existence with various agricultural activities without deleterious effects.

The development of an Environmental Impact Report (EIR) and SEO in accordance with the PGE Act requirements mandates all potentially affected stakeholders (including farmers) the right to be consulted and to raise any issues and concerns (including those associated with other uses of the land) well ahead of land access and to be engaged in process of government setting acceptable environmental outcomes in the relevant SEO(s). In addition, the required notice of entry to land process under Part 10 of the PGE Act provides ample opportunity for landowners to negotiate proper land access conditions and any commercial terms for such access, including compensation for:

- any deprivation or impairment of the use and enjoyment of the land;
- damage to the land;
- disturbance to business or other activity lawfully conducted on the land; and
- any consequential loss incurred as a result of the entry to land.

The notice of entry to land process provides the landowner with rights to dispute entry and to seek resolution on terms of entry through a delegate of the Minister for Mineral Resources and Energy acting as a mediator (and by policy, through the appointment of a knowledgeable, independent and highly regarded person). As a last resort, failing to have this resolved to the satisfaction of both parties, the matter may be referred to the Warden’s Court. The broad scope of compensation provisions under section 63 of the PGE Act ensure that landowners (including farmers) are not disadvantaged by the coexistence of petroleum activities on their land.

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23 Section 63 includes compensation for actual loss of use, damage and enjoyment of the land, but also potential impacts on the landowners business, any consequential losses, and compensation for the time and trouble involved in managing their business in co-existence with petroleum activities.
Seismic impacts

There is a thorough understanding of the micro-seismic activity associated with fracture stimulation in the petroleum industry. Fracture stimulation operations generate micro-seismic events that can be recorded with sensitive listening tools and analysed with established scientific methods. There have been no cases of injuries or damage as a result of the very low level of seismicity related to fracture stimulation\textsuperscript{24}.

The results from one study\textsuperscript{25}, which assessed thousands of fracture treatments in US shale plays, showed that the largest micro-seismic event recorded had a measured magnitude of approximately 0.8. This is approximately 2000 times less energy than a magnitude 3.0 earthquake. The magnitude 3.0 earthquake is commonly used to describe deep earthquakes that can be felt at the surface, but still much smaller than an earthquake that could be damaging or harmful.

Surface water impacts

Transport issues, particularly related to road use and potential truck rollovers, can also create water contamination risks. Contamination of surface water can also come from a variety of other sources, including drill pad construction and operation, spillage/leaching from cutting/mud pits, spillage of fracturing fluids and flow-back fluids, and loss of containment of stored flow-back fluids.

Floodplain management, and ensuring that the pad and associated facilities do not overtop or drown, bunding, etc. must be planned-for, to avoid potential, undesired outcomes.

In the South East, there is an extensive drainage system. Management of the entire South East drainage system is now covered by the \textit{South Eastern Water Conservation and Drainage Act 1992} (SEWCD Act). Previously the South Australian Government proclaimed the \textit{Upper South East Dryland Salinity and Flood Management Act} (USE Act) in December 2002 to facilitate and support the delivery of the USE Dryland Salinity and Flood Management Program. The USE Act expired on 19 December 2012 and arrangements were put in place to ensure a smooth transition for the day-to-day operations and management of the drainage system and infrastructure. The purpose of the SEWCD Act is to provide for the conservation and management of water and the prevention of flooding of rural land in the South East. The South Eastern Water Conservation and Drainage Board are responsible for assessing applications for licences to undertake private water management works relating to the drainage system, within the South East Region.


Inquiry into unconventional gas (fracking)

Waste water disposal

Waste water is produced in oil and gas operations mainly during production from some conventional reservoirs and when a portion of the fracturing fluid returns to the surface after hydraulic fracturing during that is called the flow-back phase.

Additional to proppant and chemicals initially present in the fracturing fluid, the returned water can pick up a variety of elements from contact with petroleum-saturated reservoirs. Traces of petroleum from the targeted reservoir can also be found in the flow-back of fracturing fluid. The contaminants in, and quantity of flow-back and produced water from unconventional gas varies from basin to basin and well to well, and may require appropriate treatment for recycling or disposal. At the same time, some water may be of sufficient quality for beneficial use without treatment.

For fracture stimulation in shale, about 1 mega-litre (ML) per stimulation stage (i.e. fracture stimulated zone) is required. Typically in South Australia, a single, vertical exploration well program for fracture stimulation entails an average of 4 stages (thus, an average use of roughly 4 ML of water). More stages are typical in horizontal production wells. For example, a horizontal shale well in the USA on average will use ~15 megalitres of water. Between 15-50% of the fracture stimulation fluid tends to be recovered during flow-back and as produced waters.

Just as for many substances commonly used for industrial and domestic purposes, several of the additives in the fracturing fluids (particularly biocides) at concentrations of transport and just after mixing, before degraded and/or further diluted (for example in a petroleum reservoir or a swimming pool) have relatively high toxicity. Although many of these additives are biodegradable and would be expected to break down over time, a release or spill to surface waters of large volumes of fluids containing these additives would require significant dilution to reduce levels of contaminants to below harmful levels and could result in impacts beyond the immediate area of operations. The avoidance of a release or spill is a standard objective of regulation for the transport and handling of all hazardous substances in the State.

Waste water disposal is regulated to avoid the following potential risks associated with all industrial and domestic activities, including oil and gas operations:

- discharge of contaminated waters into waterways;
- delivery to unsuitable treatment works;
- spills due to improper surface handling of wastewater; and
- salt waste – a by-product of water treatment and salt recovery processes – that may also create a concentrated salt waste stream, which can present an important waste disposal issue, particularly in arid landscapes that are already sensitive to salt load.

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Effectiveness of existing legislation and regulation

In South Australia, all onshore oil and gas exploration and production activities are administered by the Department of State Development (DSD) under the Petroleum and Geothermal Energy Act 2000 (PGE Act) and associated Regulations. The objectives of the PGE Act and its Regulations are to ensure that all risks to the health and safety of the community and to the natural, social and economic environments are either completely avoided, or managed and reduced to a level that is as low as reasonably practicable and acceptable to the community. Furthermore, under the PGE Act it is an offence for any regulated activity, in this case drilling and well operations, to cause, amongst other things, contamination of underground aquifers.

In contrast to interstate regulatory processes, the PGE Act mandates a clear role for early public participation and engagement in identifying potential risk of a proposed activity, and the environmental outcomes to be achieved set by the government in approving an SEO. In addition, public reporting on compliance is required under the PGE Act.

The PGE Act is not prescriptive in approach, but rather takes an objective/ risk based approach, which is considered best practice for modern regulation. Key features of this approach are as follow:

- The focus of the PGE Act is on approving environmental outcomes to be achieved by the company undertaking the activity;
- The focus of the PGE Act is on what should be achieved (outcomes) not how it should be achieved);
- The PGE Act ensures that the responsibility to achieve these rests entirely with the company, not the government;
- The PGE Act ensures that the company is encouraged to innovate and adopt new technologies as appropriate;
- The PGE Act is adaptable to specific activities and locations to ensure “fit for purpose” regulation;
- Stakeholder input critical to setting outcomes pursuant to the PGE Act; and
- The PGE Act requires the regulator to assess capability to achieve outcomes (management systems), and in doing so, puts a consequential focus on the prevention of mishaps.

For the community, this approach aims to be inclusive, predictable and transparent. Clear environmental outcomes are set and achievement can be demonstrated to stakeholders, which in turn would be expected to build trust in the government as regulator. For Government, because the methods used are not prescribed under legislation, liability for failure (i.e. remediation) clearly rests with the company undertaking the activity.

If a company proposes to undertake fracture stimulation, under the PGE Act, a comprehensive and extensive public consultation process is required to be undertaken, demonstrating how all potential risks to social, natural and economic environments can be managed to meet
community expectations for net outcomes. This of course includes the management of potential risks to water resources. Only at such time that community concerns have been adequately addressed and all significant risks are effectively managed would the Minister for Mineral Resources (on advice of technical government regulators) consider granting approval for fracture stimulation operations.

It is an offence under several Acts in South Australia for any activities, including fracture stimulation operations, to cause aquifer contamination and adversely impact on potentially affected people, the natural ecosystems or enterprises. The significant penalties associated with these provisions provide strong drivers for industry to prevent and avoid any contamination, regardless of the PGE Act approval process.

All activities regulated under the PGE Act are also subject to the provisions of other state environmental regulation such as the National Parks and Wildlife Act 1972; the Natural Resources Management (NRM) Act 2004; the Work, Health and Safety Act 2012; the Environment Protection Act 199; Dangerous Substance Act 1979 and its regulations; Dangerous Substances Regulations 2002 and Dangerous Substances (Dangerous Goods Transport) Regulations 2008. This in turn creates additional layers of protection in addition to the best practice regulatory regime under the PGE Act. The PGE Act enables one window to government for the industry whereby, through the SEO as a regulatory instrument under the Act, the requirements of other relevant pieces of legislation are incorporated into the Department of State Development’s Energy Resources Division (DSD-ERD) approval and compliance monitoring processes.

Approvals for the development of South Australia’s natural energy and mineral resources are informed by technically competent and experienced regulators using the best available science and engineering information with the aim of ensuring only environmentally sustainable projects are provided with land access. In other words, where a project cannot demonstrate that it can be undertaken in manner which will comply with the regulatory requirements, that is to be environmentally sustainable, then approval for that project will not be granted.

The current South Australian petroleum regulatory framework has recently been endorsed as one of the top three resource regulatory regimes in the world by international mining and energy law expert Dr. Tina Hunter for shale and tight gas. Dr. Hunter has been quoted that it was one of only three – Western Australia, South Australia and the UK’s Department of Energy and Climate Change (DECC) - that she recognized as competent regulators:

“In my view they are professional and have the necessary experience and processes to implement best practice in the regulation of unconventional natural gas”.

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Does Statement of Environmental Objectives (SEO) exist for proposed activity that addresses all potential risks associated with the proposal? 

Yes

Prepare and submit Environmental Impact Report (EIR) and draft SEO.

Prepare and submit environmental assessment against existing SEO for review and consideration by DSD.

If activity involves coal seam gas, refer EIR and draft SEO to the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development.

Undertake Environmental Significance Assessment to determine level of environmental impact. **10 business days.**

Note: Activities that significantly impact MNES under the EPBC Act will be at least medium impact.

Low impact

Consult on determined low level of environmental impact with:

*Environment Protection Authority (EPA); and
*Department of Environment, Water and Natural Resources (DEWNR);
Comments within 10 business days.

Medium impact

Consult on determined medium/high level of environmental impact with the Department of Planning, Transport and Infrastructure (DPTI).

Comments within 10 business days.

High impact

Consider comments and classify the environmental impact of proposed activities. **5 business days.**

**LOW IMPACT**

Consultation on EIR and draft SEO with:

*EPA;
*DEWNR;
*SafeWork SA; and
*DPTI, if activity is within a council area or a part of the State described in Schedule 20 of the Development Act 1993.
Comments within 20 business days.

**MEDIUM IMPACT**

Public consultation on EIR and draft SEO with:

*EPA;
*DEWNR;
*DPTI;
*SafeWork SA;
*Relevant statutory authorities;
*Relevant local councils;
*Landowners;
*Key stakeholders; and
*General public.
Comments within 30 business days.

**HIGH IMPACT**

Assessment and consultation under the Development Act 1993. At least 7 months.

Refer draft SEO to the relevant Minister/DEWNR for:

*Approval, where it covers any area within a National or Conservation Park.
*Concurrence, where it covers any area within or adjacent to a Marine Park, the Adelaide Dolphin Sanctuary, the River Murray Protection Area or the Murray-Darling Basin.

Refer draft SEO to DEWNR for:

*Consultation, where it covers any area within a Regional Reserve.

Response within 20 - 60 business days.

Note: This referral/consultation usually occurs in parallel with consultation on the Environmental Significance Assessment.

Consider comments and amend EIR and/or draft SEO as required.

Have significant changes been made to EIR and/or draft SEO document that warrant further consultation?

Yes

SEO APPROVED
Approval decision published in SA Government Gazette. 5-10 business days.

No

SEO NOT APPROVED

Figure 7: Stage 2 in the licensing and approvals process for exploration, retention, production and associated activities pursuant to the South Australian Petroleum and Geothermal Energy (PGE) Act 2000. (Dashed line box = initiated by proponent/licensee, solid line box = initiated by DSD)
Environmental assessment and approval

Figure 7 details the environmental assessment and approval process under the PGE Act.

Regulated activities under the PGE Act (under section 96) may not be carried out unless an approved SEO is in place, prepared on the basis of an EIR. The EIR describes the specific features of the environment where the activities will take place and identifies all potential impacts, the 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.

Examples of the information and potential impacts that the EIR and final SEO are expected to address include:

- impacts on aquifers, including pressure and contamination;
- impacts on groundwater use;
- contamination of surface water and shallow groundwater;
- soil contamination;
- impacts on native vegetation and native fauna caused by clearance required for above-ground infrastructure (e.g. track clearance, water storage ponds, flow-back storage ponds, other infrastructure, etc.);
- interaction of stock or native fauna with water storage ponds;
- potential impacts of introduction or spread of pest plants and animals;
- disturbance to existing land uses (e.g. within reserves under the National Parks and Wildlife Act, pastoral land, etc.) or to local heritage features;
- air pollution and greenhouse gas emissions;
- impacts on the health and wellbeing (including traffic and noise) of the local community; and
- remediation and rehabilitation requirements.

Division 3 of the PGE Act and Part 3 of the Regulations describe the information that must be provided in EIRs and SEOs.

Potential impacts on Matters of National Environmental Significance (MNES) as defined under the EPBC Act can also be addressed in the EIR and SEO where relevant.

Through the consultation requirements of the PGE Act, stakeholders, including landholders and other government agencies, are required to be informed and consulted on the potential risks associated with proposed activities, and management strategies are to be deployed to minimise such risks to an acceptable level. Stakeholders are also provided with opportunities to raise any issues of concern they may have prior to the commencement of regulated activities. Other
agencies with the duty of care for ensuring that the objectives of the legislation they administer are met are consulted to ensure their requirements are included within the objectives detailed in the SEO.

DSD expects licensees to initiate consultation with stakeholders 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 concerns to ensure that they are addressed within the EIR and SEO.

Once an EIR and draft SEO have been prepared and submitted for assessment, DSD uses the information provided in the EIR to complete an environment significance assessment to determine the level of environmental impact of the activity. The significance assessment is conducted in accordance with publicly documented criteria\(^\text{29}\) to assess the level of certainty in the predicted impacts such as those listed above and their potential consequences related to the proposed activities and the degree to which these consequences can be managed. The environmental significance criteria enable identification of deficiencies in stakeholder consultation during the development of the EIR and draft SEO. Where DSD’s assessment identifies such a deficiency, the determined level of environmental significance may be greater and likely to trigger more extensive stakeholder consultation by DSD. 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 a level of significance for each event relating to the activity, cumulating in the determination of an overall level of environmental impact of the activity as low, medium or high. The level of environmental impact assigned to a particular activity in turn determines the consultation that DSD undertakes, both with co-regulatory agencies on the level assigned, and more broadly on the content of the EIR and draft SEO documents. The consultation arrangements are outlined within the PGE Act and regulations and within administrative arrangements between DSD and its co-regulatory agencies, which are all available on the DSD website.\(^\text{30}\)

Concerns raised during consultation are incorporated into the EIR and draft SEO documents as appropriate, enabling changes to address the comments prior to approval by the Minister. As noted previously, all of this happens before any company can apply to undertake any on-ground activities regulated pursuant to the PGE Act.

Notwithstanding that the Minister’s approval of an SEO will incorporate the input from the consultation process, any final decision which may not satisfy any legitimate stakeholder concerns is subject to a review and appeal process pursuant to Part 15 of the PGE Act and, as a last resort, by application to the District Court of South Australia. All SEOS and associated EIRs are public documents and can be found on the DSD website, referenced above.

\(^{29}\) See www.pir.sa.gov.au/__data/assets/pdf_file/0018/27702/environment_criteria.pdf
\(^{30}\) See www.petroleum.DSD.sa.gov.au/environment/regulation/admin_arrangements
The Department of Environment, Water and Natural Resources (DEWNR)

DEWNR is a referral agency under the PGE Act and is provided SEOs for comment and advice on a range of matters, including water issues related to petroleum production. All proposals are considered by the Department on a case by case basis utilising a risk based assessment framework.

The Natural Resources Management Act 2004 (NRM Act) provides the statutory framework requiring the sustainable and integrated management of natural resources, including water. The Government’s current policy position, as articulated in Water for Good, is that mining and petroleum ventures must provide their own water supplies within the requirements of the NRM Act, just like any other water user. This applies even if an activity is already approved under the PGE Act or the Mining Act 1971.

Groundwater, watercourse and surface water can be prescribed pursuant to Chapter 7 of the NRM Act. Highly valued water resources are prescribed to protect their integrity and ensure proper management and sustainable use. Prescribed water resource areas are managed through a water allocation plan (WAP) that among other purposes, sets the limit on the volume of water that can be taken and used, with the aim of ensuring the long-term sustainability of the resource.

WAPs are developed by regional Natural Resources Management Boards and adopted by the Minister for Sustainability, Environment and Conservation. Their implementation is administered by the Department of Environment, Water and Natural Resources in partnership with the relevant NRM Board.

A water licence is required to take water from a prescribed area, under the conditions set in the relevant WAP. In regard to potential unconventional gas exploration and development in the South East, the relevant WAP is the Lower Limestone Coast Water Allocation Plan31.

The Lower Limestone Coast WAP does provide for the Minister for Sustainability, Environment and Conservation to grant allocations from the confined aquifer for the purpose of petroleum and carbon dioxide production, however, the WAP limits this allocation to water taken as a by-product of petroleum or carbon dioxide production (known as co-produced water or produced formation water). Water used in unconventional gas production, including for the drilling process or for use in fracture stimulation, is not co-produced water. No water is available for allocation from the unconfined aquifer in the Lower Limestone Coast Prescribed Wells Area for the purpose of petroleum production. A new allocation cannot be issued by the Minister under the Lower Limestone Coast WAP for the purpose of petroleum production for water that is not co-produced water from the confined aquifer. Where no water is available for allocation for the purposes proposed, in prescribed areas, the proponent will need to purchase a water allocation

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31 For further information visit: http://www.senrm.sa.gov.au/Water/TheLowerLimestoneCoastWAP/AdoptedLLCWAPinformation.aspx
from another licensee, subject to any requirements of the relevant water allocation plan, including hydrogeological assessment.

In addition, authorisations to take water for a particular purpose without a licence can be granted by the Minister for Sustainability, Environment and Conservation under s128 of the NRM Act.

For the purposes of petroleum exploration only, there is currently such a state-wide Ministerial authorisation in place. Drilling and exploration well has a ‘one off’ requirement of 1 to 2 megalitres (ML) of water in total, depending on the depth of the drill. This water is mostly for making up well drilling mud and cement used in the well casing process. Similarly, water used to drill a water well for irrigation does not require a water licence. Other exploration water needs may include camp services, pump testing, and fracture stimulation that is part of the exploration process.

Outside of prescribed water areas there is no requirement to hold a water licence to extract water for mining or petroleum activity. However, the principles of regional Natural Resources Management Plans (NRM Plan) still apply. This is managed through water affecting activity permits and requirements as set out in the regional NRM Plan. Volume 4, Section 4 of the South East Natural Resources Management Plan outlines various water affecting activity requirements that would need to be complied with for any unconventional gas exploration or development in the South East, alongside the water allocation plan. The erection, construction, modification or removal of a dam, works in watercourses or lakes or on the floodplain of a watercourse, draining or discharging water directly or indirectly into a water course or lake, or destroying vegetation growing in a watercourse or lake or growing on the floodplain of a watercourse, are some examples of water affecting activities that require a permit prior to the works being undertaken. There is the potential for Best Practice Operating Procedures to be developed with mining or petroleum companies for specific water affecting activities, which may result in a water-affecting activity permit not being required. Agreement on Best Practice Operating Procedures must be signed off in writing by the Natural Resources Management Board and obtained prior to the commencement of the activity.

South Australia is also a signatory to the National Partnership Agreement on Coal Seam Gas and Large Coal Mining and has established protocols and processes that enable the referral of such projects to the Commonwealth’s Independent Expert Scientific Committee (IESC) for advice on water related matters. Any advice received on such projects by the IESC is considered as part of approval processes under the PGE Act.
The Environmental Protection Authority (EPA)

During exploration, the EPA acts in an advisory capacity to DSD.

The EPA regulates off site activities associated with exploration under the *Environment Protection Act 1993*, for example the transport of waste from the lease site against waste transport and disposal requirements.

The *Environment Protection Act 1993* and its associated Policies applies to companies or individuals undertaking petroleum production activities.

The EPA works with DSD to provide advice through their SEO and EIR process. The EPA is listed as a mandatory referral agency within the *Petroleum and Geothermal Energy Regulations 2000*.

For exploration activity referred to the EPA for assessment and comment, the EPA considers whether the proposed risk ranking is appropriate, and advises DSD.

Based on identified environmental risks of proposed activity, proposals are reviewed by EPA technical experts in the fields of water quality, air quality, waste, radiation or site contamination. Assessment of the environmental risks associated with the activities, and the appropriateness of the proposed mitigation measures are considered. Advice is then provided to DSD for consideration and inclusion in the proposal.

Above certain thresholds, an authorisation (licence) from the EPA is required to undertake activities. These thresholds are set out in Schedule 1 of the *Environment Protection Act 1993* – categories that may be applicable are:

- Petroleum production or storage;
- Discharges to marine or inland waters;
- Chemical works and chemical storage facilities;
- Waste or recycling depots; and
- Fuel burning.

This licence sets conditions under which the company is permitted to undertake their activities. These conditions may include monitoring and reporting requirements, based on the environmental risk associated with the activities being undertaken.

If a company or individual does not meet these threshold criteria, they are still required to meet the requirements of the relevant Environment Protection Policies, the General Environmental Duty (Section 25 of the Act) and other requirements such as incident notification requirements. In addition, the general offences under the Act (with maximum penalties of $2m for actual / potential serious environmental harm) apply.

As both the EPA and DSD have a regulatory role in the production phase, the two agencies have also established an Administrative Arrangement (AA) and a Memorandum of
Understanding (MOU). The two agencies meet regularly to ensure that regulatory approaches are effective and efficient.

The Administrative Arrangement\(^{32}\) outlines the responsibilities of each agency, and also identifies which agency takes the lead on potential environmental incidents.

**Potential net economic outcomes to the South East region and to the rest of the State**

It is most important to understand that the Crown (i.e. the community) retains ownership of any natural gas contained in the ground for onshore South Australia. Unlike the US, neither the local landowners nor the petroleum industry have rights to the resource, and hence the development of these resources needs to be assessed in the wider (state-wide) public interest. Ownership of a regulated substance transfers to a licensee upon recovery of the regulated substance on which a royalty is levied. This royalty is in addition to the Commonwealth, state and local government taxation regimes to which all companies and individuals are subject. Royalty payments become a source of capital for State governments to deliver services and infrastructure that are of benefit to all South Australians, including those in the South East.

Natural gas remains a critical form of energy for thousands of South Australian families, businesses (including agriculture) and industry – whether through direct gas supply, or via electricity generated from natural gas or as feedstock for fertilizer and other products widely required for South Australian enterprises. In 2013, 52% of the State’s electricity was generated from natural gas. Natural gas is a lesser source of greenhouse gas emissions per kilowatt hour (kWh) of generated electricity than is coal, and hence is a preferred fuel for electricity generation on that criterion.

Increased local supplies of natural gas means lesser pipeline tariffs and hence lower prices for South Australian gas users, as a significant component to the supply of natural gas to consumers is the cost of transport via pipeline. Without development of gas resources in South Australia, supplies will come from a greater distance away, and most likely come from interstate, at a greater cost, and will make local energy intensive industries less competitive (in proportion to natural gas pipeline tariffs) compared to the other Australian jurisdictions that are located closer to natural gas fields.

The magnitude of economic benefits from any natural gas development in the South East to the regional community and the state overall in terms of industry development, employment, infrastructure development, royalty and security of energy supply can be demonstrated by results to date, and with forecasts based on reasonable assumptions. While the magnitude of future benefits will ultimately depend on the total size and quality of any commercial discoveries, existing fields that have produced gas provide a reality check for potential future discoveries.

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The Katnook area gas field discoveries have conventional reservoirs that flowed at economic rates without fracture stimulation. The total gas production in the term 1991–2011 was over 66.31 billion cubic feet of sales gas (equivalent to 7,002,360 gj) of natural gas and 432,782 barrels of gas liquids (condensate) over a 30 year period. At a modest (for current) sales gas value of $6 per gigajoule (gj) and $74.00 per barrel of condensate (as roughly the current value of US$60 per barrel for Brent crude and 0.81 US$ per Australian $, this equates to $420 million in dollars-of-today value for natural gas sales and $32.2 million in dollars-of-today value for condensate sales. Total royalty that would be expected to be paid to the state of South Australia would amount to $30.5 million from gross sales revenue of $452.2 million. Furthermore, these discoveries resulted in the gas pipeline network stimulating new local industry and included the construction of the Ladbroke Grove and Snuggery power plants and Safries Chip factory. The Kimberly-Clark Australia Pty Ltd paper mill and the city of Mount Gambier were also converted to natural gas, which was a more cost effective fuel than that previously used. Once these local fields commenced decommissioning around 2005, gas supply continued through this infrastructure with gas delivered through the South East South Australia pipeline connected to the SEAGas pipeline delivering offshore Otway Basin gas to South Australia.

The prospects for natural gas and condensate in unconventional reservoirs in the onshore Otway Basin is yet to be established, but if even modestly successful, potential production in future could easily be a multiple of the gas and condensate recovered to date from the Katnook area gas fields.

While the metrics documented since 2009 from the US experience need be scaled down to the relatively modest (by comparison) extent of the potential for unconventional gas reservoirs in the Otway Basin, I.H.S studies undertaken to better understand and quantify the economic contributions associated with just the development of natural gas and gas liquids in shale gas resources in the USA.

While the market prices of oil and gas sold at an oil-based price (for the manufacture of LNG) have declined in recent months, the prices for gas to supply Asian LNG markets and Henry Hub gas prices (in the USA) in 4Q 2014 were relatively stable and/or increased. Northern hemisphere winter weather is expected to be factor in affecting supply: demand and prices for international LNG prices. That is offered as a caveat in restating the I.H.S study conclusions as follow:

- The total number of jobs supported is expected to rise to 3.3 million by 2020 – with 1.8 million of those jobs from shale gas.
- In 2012, the shale gas revolution added $74 billion to US federal and state government revenues.
- Currently, natural gas in unconventional reservoirs accounts for nearly 67 percent of total U.S. lower-48 natural gas productive capacity and is projected to rise to nearly 75 percent by the end of the decade.

• Owing to the long supply chains in the USA, the job impacts are being experienced across the United States, including in states without significant shale gas or tight oil activity, more than a quarter of all jobs associated with the unconventional oil and gas revolution are found in states with no appreciable unconventional activity.

• The unconventional gas revolution increased average household disposable income in 2012 by $1,200 as a result of supply-side competition impacting favorably on the cost of utilities and lower costs for goods and services.

The Australian Council of Learned Academies (ACOLA) Report, referenced above, notes that economic diversification that leverages energy projects is the greatest way of contributing to the long term wellbeing of a region, though a strategic approach to regional development is vital.

Conclusions and key points

It is concluded that the potential for deep natural gas in the South East of the state, which may be exploited using fracture stimulation technology can be trusted to be conducted without significant or unacceptable controlled risks to the environment, people or enterprises and would deliver significant benefits to the wider South Australian community.

In summary, the key points of this submission are:

• In the South East of South Australia there has been no fracture stimulation to date, nor has there been any proposal to government for fracture stimulation in this region of the State. Until a proposal is made and the process pursuant to the PGE Act is followed to demonstrate how all significant risks (identified in consultation with the public) will be avoided, fracture stimulation is not permitted in the South East.

• Fracture stimulation has been demonstrated to be safe and without harm to social, natural or economic environments in more than 700 wells in the Cooper Basin of South Australia.

• Conventional gas exploration, development, production, processing and transport have been conducted for over 100 years in the South Australian Otway Basin, which includes over 100 petroleum wells drilled. Despite these activities being located in the highly valued Coonawarra wine growing region of the South East, the landowners concerned have been demonstrably able to continue their various agricultural activities in compatible, contemporaneous coexistence with the petroleum activities. Outcomes have been demonstrably safe and without significant, perceptible, associated, negative impacts on natural environments, enterprises or the health and safety of people. The additional potential risks associated with fracture stimulation are considered to be similar to conventional drilling, and manageable.

• Beach Energy have publicly stated that their focus for exploration is now be on deep conventional gas reservoirs in the South East within the footprint of existing gas fields. No other companies have publicly stated their intention to explore for unconventional gas reservoirs in the South East.
• A comprehensive and extensive public consultation process will be undertaken in the event that fracture stimulation is proposed in the South East. Only if community concerns have been adequately addressed and it has been demonstrated that all significant risks are effectively managed to protect: (1) the natural environment - including the precious water resources of the region; (2) the social environments; and (3) potentially affected enterprises – will the government then consider granting approval.

• The deep natural gas resources being targeted in the South East are not shallow Coal Seam Gas (CSG) resources, and hence the operations that may be proposed at some time in the future will not pose:
  o the same sort of logistical conflicts that could arise between land use such as farming and the a semi-grid-like pattern of wells connected by gas gathering flow-lines, and with an access path to each wellhead; or
  o potential risks to shallow potable water supplies owing to the proximity of shallow CSG reservoirs to shallow aquifers.

• The potential risks from potential fracture stimulation operations to the aquifers (used by people and enterprises in the South East) are extremely low, due to the fact that fracture stimulation is designed to only affect targeted reservoirs and that its impact is limited to less than 600m vertical height, whereas the unconventional gas reservoir targets in the South East are at depths below 2,800 metres and the aquifers at less than 500m. Most of the vertical separation from the shallow aquifers comprises rocks that are natural seals that prevent flow from deep to shallow levels.

• The potential risk of contaminating shallow aquifers due to well integrity failure are extremely low, due to leading practice operations deployed by South Australian Petroleum Licence operators and the high level of regulatory control over the drilling and completion of wells. All projects are considered and assessed under the State’s regulatory framework on a case by case basis using a risk based methodology.

• Potential impacts from fracture stimulation to landscapes are minimized due to the ability to drill multiple wells from a single location (multi-well pad) limiting the surface foot-print of developing and producing from deep gas reservoirs.

• Gas exploration, development and production activities are temporary (5-10 years) and compensable, and the pre-existing landscapes can be fully restored after the wells have ceased production.

• The existing regulatory regime in South Australia is world class and has been independently assessed as one of the top three resource regimes in the world by international mining and energy law expert Dr. Tina Hunter for shale and tight gas.

• Based on the US experience, the potential economic benefits to South Australia, successful exploration for, and subsequent development of natural gas in unconventional reservoirs is likely to be significant and similar to that derived from conventional gas development.

DSD-ERD will welcome the opportunity to appear before the Committee to discuss the points raised in this submission.