INFORMATION REQUEST RESPONSE TO THE SCIENTIFIC INQUIRY INTO HYDRAULIC FRACTURING IN THE NORTHERN TERRITORY



Document Number:	170823_Pangaea_Response to Scientific Inquiry into Hydraulic Fracturing_Information Request
Title:	Information request response to the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory.
Author:	Pangaea (NT)
Date:	23 August 2017

APPROVAL FOR EXTERNAL RELEASE

Tim Radburn	
Executive Director	
Pangaea Resources Pty Ltd	(a)

Date : 23/08/2017

Table of Contents

Appendices	3
Attachments	3
Enclosures	3
Introduction	4
Social Assessment	4
Regulation	6
Economic Assessment	7
Infrastructure requirements	8
Development Scenario	10
DPIR numbers	11
Planned Infrastructure	11
Sealing of the Western Creek Road	11
Header pipeline	11
Pad sizes	11
Rail siding	12
Water	12
Scenario 1 and Scenario 2	12
Groundwater Systems	12
Spills	14
Flowback and produced water	14
Solid Waste Management	15
Greenhouse Gas Emissions	15
Traffic	17
Public Health	17
Conclusion	18

Appendices

Attachments:

1. Map of Pangaea EP 167 and 168 (access infrastructure improvements and upgrades)

Enclosures:

- 1. Environmental Management Plan 2015 (stimulation and testing)
- 2. Emergency Response Plan 2015
- 3. EcOz Surface and Groundwater Characterisation Report
- 4. Environmental Management Plan 2015 (appraisal wells)
- 5. Traffic management plan 2014

Introduction

Pangaea would like to thank the Inquiry for seeking further information on issues identified in the Interim Report and enabling an opportunity to respond with an additional submission. It is Pangaea's view that the social and economic benefit of development of an onshore gas industry (enabled through hydraulic stimulation) does not need to come at an environmental or social cost. Pangaea would like to see a successful onshore gas industry grow in the Northern Territory in a way that enables the growth, success and public benefit Territory wide. An outline of Pangaea's operational area is displayed in Attachment 1.

Pangaea achieves its **'NT Way'** approach to business based on **world's best geological analysis**, combined with **industry best practice innovation and technology**. This forms a nexus that creates sufficient flexibility to design operations around attainment of **Territory best social benefit** (retention of social license to operate). Pangaea takes very seriously the views and opinions of all Territorians and assert that with appropriate regulation the industry can continue to grow to ensure best practice is nested with proper protection of the environment, Territorians and employees.

Social Assessment

The issue of gaining and maintaining a social license to operate (SLO) is in effect a common-sense approach to seeking license from those who have a direct interest in the land and its surrounding communities, prior to and during development of that land (Pangaea views this as the 'NT Way'). It is acknowledged that it goes further than this though, because Social License whilst primarily concerned with gaining trust and acceptance of the local people who have to live with any development, is in effect one tier of a two tier system to gain Social Agreement (Table 1). The second tier is Social Consensus, and it is achieved through the acceptance of a broader society whom retain an active interest in the human, cultural and flora/fauna ecosystems that exist on and around the land concerned. A company must gain and maintain a Social License in a given area through the attainment of deeds, agreements and contracts with local stakeholders (such as Pangaea's current SLO in its exploration permit boundaries in the Beetaloo Sub-basin which can be assessed and confirmed presently). A company must also gain broader Social Consensus by addressing wider issues surrounding its operations in a given area through compliance with all legislation and regulation set by the NT Government as the elected representatives of all Territorians (the key concern of impact on sub-surface aquifers being regulated by enforced application of best practice technology, engineering and environmental compliance to genuinely reduce the risk to as low as reasonably practicable).

Whilst the technical granting of permission to commence operations rests at the local level achieved through attaining the necessary deeds, agreements and contracts, the degree of social benefit achieved by granting an SLO can also be proven. This can occur through measurement of a baseline (environmental, stakeholder education, cultural engagement) prior to exploration commencing, assessing the current situation in exploration and early appraisal, and certainly through the development and production stages. This baseline should consider the degree of access to life improving infrastructure (power, roads, medical, supply, water and security) before, during and after; the degree to which industry engages with and acts upon the views of the local community and the consideration as to the genuine trust and acceptance of the industry. The view should be considered on a Sub-basin level across the industry to establish necessary standards, but elements of best practice from specific Companies should be highlighted and promoted commonly ensuring that the Industry as a whole leads the way.

Table 1. Attainment of Social Agreement – Social License and Social Consensus

		Sod	cial Agreement	
	Stakeholder	Current Legislation and Policy	Enhancement to current Legislation and Policy	Document
Social License	Land Owners	Petroleum Act 2015	Incorporate general Land Owner agreement process into Requirements	Access and Compensation Agreement
		Schedule of Onshore Petroleum Exploration and Production Requirements		
	Traditional Owners	Native Title Act 1993	Incorporate Indigenous training and employment programs into Policy	Co-existence and Exploration Deed
		Aboriginal Land Rights (NT) Act 1976		
		Aboriginal Land Act 2010		
		Aboriginal Sacred Sites Act 2004		
		Northern Territory Aboriginal Sacred Sites Act 2013		
	Local Government	Building Northern Territory Industry Participation Policy	Apply local content qualities to non-Government Industry	Contracts between Company and local/NT husinesses
	(representing the local community)	Buy Local Plan	Establish Gasfield Commission	
Social Consensus	NT Government	Petroleum Act 2015	Incorporate social impact consideration into EMP requirement	Environmental Management Plan (EMP)
	(representing all Territorians)	Northern Territory Environment Protection Authority Act 2012	Consider project based hydraulic stimulation into NOI requirement	Notice of Intent (NOI)
		Environmental Protection and Biodiversity Conservation Act 1999		
		Environmental Assessment Act 2013		
		Environmental Offences and Penalties Act 2011		
		Territory Parks and Wildlife Conservation Act 2011		
		Water Act 2016		
		Public and Environmental Health Act 2011		
	2	Soil Conservation and Land Utilisation Act 2009		
		Weeds Management Act 2001		
		Plant Health Act 2008		
		Waste Management and Pollution Control Act (year)		
		Heritage Conservation Act 2008		
		Heritage Act 2012		
		Bushfires Act 2009		
		Fire and Emergency Act 2004		

ഹ

The inclusion of demonstrable actions to gain Social License could and should be incorporated into refinement and improvement of the *existing* process of submission of an Environment Management Plan to the Department of Primary Industry and Resources (DPIR) and EPA, displaying confirmation that all deeds, agreements and contracts are in place. Where development is extensive (including where hydraulic stimulation and flowback occurs in wells that intersect potable groundwater systems), an element of proving actions to gain Social Consensus should occur through the submission of the existing Environmental Management Plan to the DPIR and a Notice of Intent at project/license level to the Northern Territory Environmental Protection Agency demonstrating full compliance with all NT and Commonwealth legislation and regulations.

Regulation

Pangaea supports the concept of play based regulation (based on the Alberta Energy Regulator pilot) provided it is developed around the unique environmental and social requirements of the NT under the purview of a Gasfields Commission (similar to the Queensland GasFields Commission). The combination of world's best geological analysis, industry best practice innovation and technology and Territory best applied social benefit in keeping with the 'NT Way' approach to business provide a sound basis for the development of *project based regulation*.

Under project based regulation, a single application that covers all regulatory requirements under the numerous acts for a scope of works in a particular license area over the timeframe of the license period would be worth consideration. This provides the flexibility required to cover exploration through to production using a system that focuses on applied principles and not red or green-tape (the period of an exploration license currently being five years, and the production license being up to 25 years). It is not expected that the detail would be provided over a five or especially 25 year period, but that the overarching concept for development over that period is provided (a development strategy that is further broken down into operational stages and in turn component activities in each year to the extent known at the time of initial submission).

It would be expected that after the first submission, with explicit detail for the first year scope of works, a yearly update would be provided (under a rolling project based plan with regulatory and governance – Commission – oversight) to report on the achievements in the previous year and set out the scope of works for the following year in further detail. In moving into the development and production phase, it would be expected that a scope of works could be completed for 3-5 years in advance. Underscoring the single application process and single year updating (similar to the current annual report requirements but tailored to a single application process) would be a tracking system that runs along the complete project timeline (be it 5 years in exploration or 25 years in production) and explicit detailing of deviations from the original project timeline based on the underlying regulatory principles.

To enable project based regulation, some quantifiable parameters may be set but the focus should be on qualified assessment to prove compliance with regulatory principles/the framework. Some quantifiable parameters could be for instance:

• a minimum space between production well pads that increases over time as technology improves but that commences with consideration for social requirements of infrastructure placement, geological (sub-surface) variabilities and recognises the timeframe required to reach best practice technology in the remote geography of the Northern Territory (specifically if production well pads in some cases need to be closer together due to such considerations, Operators would be able to apply for special consideration);

- a total number of well pads based on the number of graticular blocks in the production licence; and
- a limit on the number of pads per block based on the minimum spacing principle, while accommodating flexibility for future innovative practices that may/will emerge.

Applying qualified assessment in accordance with regulatory principles is however a much better approach, with an example being the removal of an upper limit on the number of graticular blocks in a single production license by instead focusing on the makeup of the production license being based on common environmental characteristics, social similarities and infrastructure benefits to the local community. The requirements of such a qualified approach still being regulated, in that blocks must still share a side boundary (side by side in any direction) and that there are no areas of significant environmental or social impact within any of the blocks that require special and detailed consideration to be applied.

This approach to regulation ensures that a single application (including the EMP with its associated baseline data collection) can be submitted for a project, which takes into account a holistic view of the environmental and social considerations prevalent across a company's operations and activities. By limiting a production license to 12 blocks as an example, creates a regulatory framework that requires the submission of multiple disjointed applications that not only highlight red-tape frustrations and unnecessary time/cost/quality outcomes to development for both the regulator, government approval process and industry; but that also genuinely undermines the necessary holistic view of the environment and sociology present across the wider landscape.

A combination of broad quantifiable parameters matched with applied qualified assessment in implementing basin wide regulation will ensure that the necessary standards of environmental and social protection are applied, allowing the industry to demonstrate Operator of Good Standing commitments to improving and benefiting the local community and Traditional Owners and at the same time ensuring that industry is not over-regulated to the point of preventing public benefit, commercial development and ultimately the development of The Northern Territory from going ahead at all.

Economic Assessment

The North American 'industry standard' is now moving towards 20 BCF, US\$ 7 million wells. This is leading to full-cycle breakeven gas prices ranging from US\$1.66/mcf to US\$3.81/mcf, with the average well breakeven well below US\$3/mcf. In addition, approximately 30% of the well drill and completion cost in North America are water and proppant (sand). Therefore, at least a third of the drill and completion well cost in the NT should be consistent with North America, particularly if utilising the existing infrastructure such as the **rail line**. In addition to this, having a "stacked play" (multiple "benches"), such as observed in the Beetaloo Sub-basin (middle Velkerri A, B and C Shales and the Kyalla Shale), allows additional wells to be drilled into multiple benches from the same pad, lowering the infrastructure requirement, surface footprint, and improving the economics of the play.

Fundamentally, it is in the Operator's economic interest to efficiently invest in infrastructure to lower the competitive cost of supply through the adoption of leading innovation and development planning. Larger multi-well pads, as opposed to smaller fewer-well pads, decreases the associated infrastructure (e.g. access roads, pipelines, water sources) needed for development. The underlying driver of how many wells and well pads are required is based on the recovery rates per well and the number of benches targeted from the well pad, which have improved dramatically over the last few years amid the spurring of step-change innovation and efficiencies required to reduce costs in a lower price environment in North America.

These innovations and efficiencies have included longer lateral lengths, greater use of proppant, optimized cluster spacing, targeted landing zones and precision geo-steering. North American Operators such as Eclipse Resources for example, have reported a 22% increase in EUR/1000 feet over the past year alone, while Range Resources have reported a reduction in well costs of approximately 65% on a per foot lateral length basis over the past five years. The geological and topographic conditions in the Beetaloo Sub-basin provides an ideal setting to apply these leading technical practices. Coupled with the flexibility to collaborate with Pastoralists and Traditional Owners on surface infrastructure locations, for mutual benefit, Pangaea can reduce the amount of cumulative surface disturbance in an orderly and responsible manner while developing valuable common use/public benefit infrastructure to improve the economics and development of all stakeholders.

Economic assessment of the potential of the basin should reflect at least three models being conservative, anticipated and progressive. Given the development is based on current findings from the exploration phase, the development scenarios produced by Pangaea reflect very conservative estimates of the recoverable resource and the rate of production has been capped based on a conservative demand scenario. The economic models being developed should start at this conservative level but should also consider anticipated and progressive models of the potential of the basin. Given the increase in rate of recovery and the reduction in cost of production being achieved in North America in 2017, an anticipated model should be based on a start state where ramp up is occurring in 2020 using at least 2016 data from North American plays. Additionally the cost of getting the gas to market is entirely dependent on which market and the applicable tariffs associated with current versus future infrastructure development, including importantly the cost of pipelines.

Given the relative potential of the basin (tens of *tcfs* recoverable) versus the local NT market (tens of *bcfs*) it is likely that gas will be used in east coast states and exported as LNG. Based on the anticipated future cost of supply (current capital and operating costs of comparable North American shale plays and the economic assessment for development of this basin even using conservative estimates of recovery) coupled with reasonable pipeline tariffs, Pangaea's view is that the development of the Beetaloo Sub-basin is competitive to global (in the case of LNG) and domestic (in the case of East Coast) markets.

However, no matter the market, the benefits will accrue to the local economy almost immediately. This is certainly true in just the appraisal stage where hundreds of millions of dollars is anticipated to be spent by Operators in the Beetaloo Sub-basin should the moratorium be lifted. The second and third order benefits to the Northern Territory economy in the development of this industry beyond the direct payment of tax, royalties and direct training & employment potential; include the construction industry, the LNG industry, the beneficiaries of infrastructure development being the cattle industry, the small business sector (with opportunities for logistics, steel, sand, water and waste management businesses to grow significantly) which according to the Northern Territory Economic Development Framework comprises 95.2% of all businesses in the Territory and the rail, logistics and freight industries. The degree in which the gas industry can boost agribusiness (and a multitude of other sectors) through common use infrastructure projects, including enhancing existing infrastructure, is considerable and in keeping with several key levers listed throughout the Economic Development Framework. The full range of benefits to the Northern Territory economy should be considered in any economic modelling of the onshore shale gas industry.

Infrastructure Requirements

Pangaea concurs with the interim report's finding that there remains a number of options for specific 'sweet spot' development locations, which is to be expected given the Sub-basin remains in the exploration and early stages of appraisal. Should the moratorium be lifted, selection of specific

development locations would be attained through the collection of additional data from further seismic, drilling and stimulations activities.

In development of future sweet spot locations, Pangaea believes that a continuation of its 'NT Way' approach to business established during the 2012-16 operations, is suitable for the forward development of the Beetaloo Sub-basin. The best practice geological analysis, the geographic location and greenfield status (specifically the absence of existing conventional wells and associated infrastructure) combined with world's best surface and sub-surface innovation and technology can be married with Pastoralists, Community and Traditional Owners goals to locate and develop mutually beneficial infrastructure. This is particularly true, as also noted in the interim report, given the Beetaloo Sub-basin has significant existing foundation infrastructure including a rail line, the highways, pipelines and associated easements, as well as numerous unsealed roads and tracks (suitable for improvements and upgrade).

During 2012-16, the tried and tested 'NT Way' approach led to numerous opportunities to best locate or upgrade infrastructure to the mutual benefit of Pangaea's operations, Pastoralist businesses (in accordance with compensation and access agreements) and Traditional Owner's (in accordance with the co-existence and exploration deed) cultural sensitivities, at Attachment 1, including:

- Location of seismic lines and well locations:
 - Traditional Owners, both Elders and their children, culturally cleared the proposed seismic line tracks (in keeping with the Native Title Agreements) which allowed them to gain access to vast portions of their Country, and in some instances allowed them to visit locations they had never seen. Traditional Owners also benefited from employment, additional income, and royalties through these activities.
 - Pangaea consulted with the Pastoralists and Traditional Owners to reduce the surface footprint by utilising where possible existing tracks and roads on the stations. Off track portions of the seismic lines were located in consultation with the Pastoralists to improve access or create fire breaks for their stations. This approach meant that approximately 55% of the 1,786 km of seismic on the Sturt Plateau (containing the Gas Discovery Area), utilised existing tracks. Furthermore, all tracks were cleared through the employment of local content generating good will, employment and minimal/suitable development of the land.
 - Upgrading of existing tracks and/or the construction of new access roads to well locations often included the widening and maintenance improvements of tracks at the request of the Pastoralist including detailed weed management. This not only improved access and movement (considering dust, noise, gates, rubbish and speed) around the pastoral stations, but also acted as new or improved fire breaks.
- Access to water resources:
 - Through consultation with the Pastoralists a number of mutually beneficial water infrastructure upgrades have occurred. Pangaea utilised local companies to upgrade existing water bores and fitting 11 out with Electronic Standing water level and chemical testing loggers. In addition, through collaborative discussions with Pastoralists, multi-user dams have been located and constructed to benefit both Pangaea's and the Pastoralists operations.

Going forward Pangaea believes the application of its 'NT Way' approach to doing business should be applied always, to ensure mutual benefit and the least amount of disturbance to the natural environment to achieve operational objectives.

Development Scenario

A 20 year indicative development scenario is presented below (Figure 1) based on application of the 'NT Way' approach. This same development scenario was submitted to ACIL Allen as a simple economic model without the social and environmental layers applied. In this example presented, the social and economic considerations - which are the first conversations had with local stakeholders – show how the final modifications to the design and layout could be adapted from the theoretical model to practical implementation. In this way the existing pastoral tracks have been utilised where possible for well pad access, the main trunk line (header pipeline), and some gathering lines. This has the benefit of allowing existing tracks to be upgraded to all-year access and reduce the overall field development footprint.

Understanding the geology and utilising North American shale surface and subsurface technology and innovation allows environmental, Pastoralist and Traditional Owner considerations to be incorporated into the surface and subsurface infrastructure locations and field design. This means that well pad and infrastructure locations can have a degree of flexibility and may not follow a perfectly prescribed grid pattern to help avoid any stakeholder conflicts. Also, the gathering lines could be buried alongside access roads and allow rehabilitation seeding options which would increase grazing area and the productivity of the station. In this scenario, the centralised gathering facilities have been incorporated onto the central well pads (red) to reduce the need for additional scattered infrastructure and fragmentation of the landscape.



Figure 1. A 20 year indicative development scenario utilising Pangaea's 'NT Way' approach to develop the field for social mutual benefit.

DPIR numbers

Per the panel's request for comment on the figures provided by the Department of Primary Industry and Resources in their submission, Pangaea would need to review the Department's underlying assumptions for the MacArthur Basin regarding this matter. The Panel's interim report provides further DPIR figures for the Beetaloo Sub-basin, and Pangaea find it challenging to comment on these figures without knowledge of the surface and sub-surface technical and commercial assumptions.

Planned Infrastructure

Sealing of the Western Creek Road

In 2015 Pangaea initiated discussions for the sealing of Western Creek Road. The initiative was widely supported by Pastoralists and multiple government agencies who appreciated the public benefit that would come from having access to an all-weather cattle station access road year-round. Pangaea contracted a local engineering firm to design, submit and project manage the works before it was postponed due to the moratorium on hydraulic fracture stimulation. The benefits to Pastoralists of the improved access from the sealing of Western Creek Road cannot be underestimated. The ability for Pastoralists to move cattle year-round would be greatly beneficial not only to the Pastoralists, but for wider public benefit. The decision to proceed with enhancing this vital infrastructure as early as the planned 2016 works program was based on the immediate benefit to the local community and Pastoralist businesses, even though the benefit to Pangaea would not have been realised until the production phase.

Header pipeline

Pangaea realised the requirement for a header pipeline as part of the pilot project for full field development, and therefor undertook preliminary engineering studies for the planning and construction of a gas header pipeline. To optimize the engineering design Pangaea acquired extensive LIDAR imagery to aid in the planning and construction of the pipeline within the local region. This imagery covers Western Creek Road and has been shared with the Northern Territory Government in order to enhance strategic government infrastructure planning and engineering design work.

Pad sizes

In regards to well and infrastructure pad sizes, Pangaea prefers to consider the overall surface footprint of the development, rather than the individual size of a pad. This is because pad sizes can vary across a project spatially and temporally depending on a number of factors. This can include if the pad is in the exploration or production phase, the number of wells per pad (which is a function of the sub-surface geology), the number of target formations and shale technology, water storage requirements and if additional infrastructure such as gathering and processing facilities are incorporated onto the well pad or require a separate pad. For example, where a surface location could have 3 target 'benches' to land horizontal wells, a well pad could contain 36 wells (12 wells per bench), plus associated surface infrastructure (e.g. centralized gathering facilities). It is also important to note the timing of developing the three benches is uncertain at this point in time, therefore the assumption of 12 well pads in Pangaea models has been used.

From the 'Evaluation of the Alberta Energy Regulator's Play-Based Regulation Pilot', a key outcome was: 'While the AER has generally observed a trend towards larger pad sizes and higher well densities in recent years, the pilot enables pilot participants to plan for longer-term development in such a way that the occurrence of these larger pad sizes with a higher well density is present in all

PBR pilot applications. In this way, pilot participants were able to reduce their overall surface land footprint.'

Also, when the geology and technology allows, having fewer, but larger pads with higher well and infrastructure densities can results in an overall reduced surface footprint. The 20 year development scenario presented in Figure 1 provides an example of incorporating the gathering facilities onto a centralised well pad, reducing the requirement for additional separate gathering stations and cleared gathering lines.

Typically well pads in North American shale plays vary from 250 m x 300 m to 70 m x 100 m (see Figure 1) depending on the factors discussed above. At the current stage of evaluation of the shale potential of the Beetaloo Sub-basin, Pangaea assumes well pads will average 200 m x 200 m (including firebreaks). However, as discussed, technology and innovation is continually reducing the overall footprint of shale gas developments. In regards to the clearing widths of access roads or pipeline corridors, and with reference to the above 2012-15 examples, Pangaea considers that they should be determined in conjunction with the interests of the operator, Pastoralists and Traditional Owners to ensure that the infrastructure meets the stakeholder's requirements.

Installation of a multi user rail siding on the Adelaide to Darwin railway line

The installation of a public benefit multi user rail siding on the Adelaide to Darwin railway line would allow the efficient carriage of consumables, drill bits and other equipment for the entire Beetaloo Basin, lowering the use of trucks on main roads and highways. The facility would be available for use by Territory businesses with the potential to increase their income by lowering their costs and dramatically improving operational safety by reducing road traffic particularly for cattle truck road transpost if they can be used or moved by rail. An example of a rail siding from the Marcellus Shale Play is shown in Figure 1.

Water

The further development of Pangaea's tenements would include working closely with stakeholders and government agencies to map a path to wider public benefit initiatives such as increased access to station water through the construction of both bores and dams, and research into potential alternative water sources. If water management infrastructure is required, options would be mapped out and planned with the direct considerations from Pastoralists and Traditional Owners.

Scenario 1 and Scenario 2

In terms of Scenario 1 and 2, or any development scenario, Pangaea agrees with the panel's desired outcome of limiting the surface footprint. This objective is compatible with, and best achieved by, qualified principle based regulatory settings that encourage the application of continued technology innovation and stakeholder collaboration rather than only prescriptive spacing.

Groundwater Systems

As part of Pangaea's 2014 and 2015 operations, a significant brackish aquifer in the Jamison sandstone within the Beetaloo Sub-basin was identified. Pangaea's interpretation is that this aquifer is non-competitive with potable water sources such as the Cambrian Limestone Aquifer. The Jamison Aquifer was intersected in five wells Pangaea drilled targeting the middle Velkerri Formation and can also be mapped regionally on the 2d seismic data (Figure 2). The aquifer is typically between ~200 to 500 metres below the ground surface and covers at least 4,000 km² (constrained by the current drilling and seismic coverage). Pangaea's intention is to evaluate this aquifer for its

future water requirements while undertaking further exploration and appraisal drilling should the moratorium be lifted.

Whilst there are several options for water usage, storage and recycling in support of drilling and stimulation operations, it is recognised that there should be clear regulation that restricts any impact on natural potable water sources. Pangaea supports the analysis of potable sub-surface aquifers for establishment of a baseline, and continuous monitoring throughout operations to ensure that any deviation from the baseline is able to be detected and responded to promptly and appropriately.

Prior to Pangaea's 2015 works program, an extensive EcOz Surface and Groundwater Characterisation Report, included as Enclosure 3, was compiled from the Cambrian Limestone Aquifer and the post-program analysis of this aquifer was completed after drilling and stimulation operations. From this analysis, Pangaea assesses that the maintenance of high standards in the integrity of its operations, enforced through regulation, will continue to have no adverse impact on any potable sub-surface aquifer.



Figure 2. Outline of known extent of Jamison Aquifer based on Pangaea seismic and drilling analysis.

Spills

Contained in Pangaea's 2015 NT Appraisal Campaign Environmental Management Plan (for stimulation and testing of appraisal wells within Pangaea EPs in the Beetaloo Sub-basin), included as Enclosure 1, and Pangaea's 2015 NT Appraisal Campaign Emergency Response Plan, included as Enclosure 2, is an analysis of risks (risk matrix) including spills, a methodology for effective mitigation of this risk and an emergency response plan to manage any unlikely occurrence. The degree to which Pangaea takes effective precautions to avoid an occurrence all together whilst still being fully prepared to respond to an occurrence is robust.

This best practice application in the early exploration phase is at a level that is in keeping with a suitable methodology for the appraisal, development, and production phases that should be continued, reviewed and further applied during every stage of development, enforced through appropriate regulation. The low risk of occurrence combined with continuous monitoring and a heightened response plan make the risk of contamination of groundwater aquifers from surface spills genuinely as low as reasonably practicable.

Flowback and produced water

It is Pangaea's view that testing of flowback water should be conducted after every stimulation and the results provided to the NT Government for monitoring and record keeping, in line with the current disclosure of all chemicals utilised in any single stimulation. Effective regulation that enforces this best practice across the Beetaloo Sub-basin is essential and full disclosure to Government is a necessary quality control measure. The chemicals used in stimulation and those present in flowback water after stimulation are not of concern provided there is no contact with intersecting potable water sources. The application of multiple well casings and tubing (separation from potable aquifers) and continuous monitoring of well integrity (noting that compromise in well integrity, requires not one, but multiple well casing failures to pose a significant risk) ensures the effective management of this waste. This combined with best practice recovery and sound recycling ensures any risk to the environment is held as low as reasonably practicable. Noting the low risk of occurrence, a well leaking into surrounding ground water systems during the stimulation, production or abandonment phase is still an important aspect of contingency planning and response procedures.

In the first instance, the most effective prevention, is to engineer well casing correctly and perform the cement job using best practices for the specific area, ensuring the quality of cement or the method used to emplace the cement is of the highest standard. However, in the rare event that a pathway were to form between the surrounding formation and a well in the production phase, anomalous pressures will begin to be measured within the well. A high quality operation will closely monitor pressures throughout the production stage of the well. In the event that a cement job either has not gone to plan, or is compromised during the production phase, the cement job may be remediated. The details of how this is done is dependent upon where the cement does not meet standards. If for example, the problem is shallower in the wellbore, the casing may need to be perforated and cement squeezed through the perforations into the space behind the casing.

After production has concluded and the well has been abandoned, several additional factors prevent fluid flow. First, cement, often in combination with steel bridge plugs are inserted into the inside of the wellbore at various levels. These cement and steel plugs provide long term barriers to fluid flow up the inside of the wellbore. They create segmented pressure cells should the casing ever corrode and/or be broken by fluids coming from the local geologic setting or tectonic stresses over time. The internal plugs are each pressure tested for assurance during the abandonment stage and are recemented in the rare cases where they fail pressure tests.

Another important aspect to this discussion is the pressure profile within the reservoir itself. During production, the formation pressures may be drawn down by upwards of 80% for permeable reservoirs initially filled with natural gas, and usually over 30% in gas-filled shale reservoirs requiring hydraulic fracturing to be able to flow gas to surface. If a pathway exists, fluids will flow from higher to lower zones of pressure. This means that fluids initially prefer to flow upward (vertically) if there is a pathway. Geological constraints are naturally present (or almost all oil and gas would have already found its way into the atmosphere through the geologic millennia). After the wellbore is plugged, the fluids left in the reservoir are no longer capable of flowing upward because the lowest pressures within a pathway are into - not out of - the reservoir. If the cement behind casing is continuous over even a tiny portion of the 30% of the bottom of the wellbore, the fact that fluids flow toward the lowest pressure in the path insures that fluids from the reservoir will not move upward.

Cement plugs should also be set inside casing adjacent to zones bearing hydrocarbons or permeable water-bearing zones. The placement of cement insures that the cement external to the casing and the casing itself is not compromised by corrosive fluids or tectonic stresses over long periods of time. If fluids do gain a path into the casing, the presence of several layers of cement plugs should mitigate the risk of the fluids continuing to move into a place where environmental harm is possible.

After all of these factors and considerations, in the exceptionally rare event that there is a leaking well during any phase of a wells life or a surface spill migrates into the groundwater system, the initial steps would be to stop the release of the contaminant and monitor the spill. Then based on the chemical composition and concentration of the spill, if required, enact appropriate remediation action based on the knowledge of contaminant and the flow paths of the groundwater system.

Solid Waste Management

In accordance with current regulation, Pangaea's 2015 NT Appraisal Campaign Environmental Management Plan (for appraisal wells in EP 167 and 168), included as Enclosure 4, indicates the plan and method for effective, safe and environmentally sound management of solid waste. This plan was enacted in the 2015 works program and where possible utilised local content to collect, re-cycle and dispose where appropriate. Due to a lack of an available certified waste management centre capable of processing drilling waste (cuttings and fluids), J.J. Richards was enacted to collect and transport all waste produced to the WestRex Services integrated waste processing and resource recovery centre in Jackson, QLD. The cost of transport of this waste such a distance was significant and not in keeping with Pangaea's preference to utilise local content wherever practically possible.

In the exploration phase it is anticipated that the process of dealing with waste will continue to be managed on an individual well/well pad basis using a combination of local business and professional service companies for specific technical tasks enabling sufficient time for the establishment of local capabilities. It is however, Pangaea's view that the construction of a centralised facility operated as a Territory business employing local people would be the best long term solution to deal with waste produced in the development of the Beetaloo Sub-basin in keeping with progression into the production phase. There are numerous locations for such a facility, with a key consideration being the optimal flow of vehicle traffic to and from a facility with potential use of the railway as a means of moving recyclable / recoverable material to other locations in the NT.

Greenhouse Gas Emissions

Pangaea's 2015 NT Appraisal Campaign Environmental Management Plan, at Enclosure 4, details the measures and procedures for the minimisation of greenhouse emissions. Within this, methods to reduce and manage the impacts on air quality due to fugitive emissions from drilling and stimulation operations are detailed. From 2015 operations, a number of measures were recognised and actions

taken to reduce emissions. For well test flaring, the duration was kept to a minimum length of time necessary to establish resource and production parameters. The volumes of gas flared were recorded, where measurable rates were encountered. The fugitive emissions from flow testing equipment were minimised by pressure testing of lines prior to use to ensure integrity. To mitigate potential migration along the well bore, the well is specifically engineered and constructed, particularly focusing on the presence of cemented casing strings, assessment of the cement quality with logging tools and monitoring the well during flowback.

There is of course a potential risk for the release of greenhouse gases into the atmosphere, particularly vented methane, from unconventional operational activities including those from well testing and production operations. The minimisation of greenhouse emissions from methane is a key priority to the gas industry as it reduces greenhouse gas emissions into the environment and has upside benefit of increased energy volumes to market. In order to reduce these fugitive losses the gas industry has been developing and implementing new technology. As recognised in the interim report and recently implemented as part of the US EPA's New Source Performance Standards, impact tanks, pneumatic devices leak detection and leak control systems. These technologies are largely responsible for the reduction in methane emissions across unconventional gas developments seen in the US (Figure 3).



Figure 3: Methane emission reduction with increase in natural gas production (Source Energy in Depth from data by EIA, EPA)

In Australia, the concern for high levels of fugitive emissions associated with unconventional gas production were addressed in the 2017 'Independent Review into the Future Security of the National Electricity Market' by Dr Allen Finkel. The report states that the associated fugitive emissions from unconventional gas production does not diminish the benefits from gas-fired power generation. As stated by APPEA in their submission, the Australian gas industry measures and accounts for all its emissions, including any fugitive emissions associated with its activities. If fugitive emissions are managed carefully they comprise only a small fraction of Australia's overall emissions. Ultimately the increased use of gas in Australia and overseas is overwhelmingly positive for the Australian and global environment compared to other low cost high energy producing sources.

Pangaea supports monitoring of air quality surrounding well pads and is investigating best practice monitoring techniques including the use of UAV (unmanned aerial vehicles) technology to support a robust regime. Going forward, Pangaea will continue to plan and operate to minimise the release of all greenhouse emissions to ensure the risk is kept as low as reasonably practicable. This will be

completed according to appropriate regulation but more importantly ensuring industry best practice is maintained.

Traffic

As per regulatory direction to Pangaea by the Northern Territory Department of Primary Industry and Resources, Pangaea commissions and enforces a Traffic Management Plan (TMP), included as Enclosure 5, which is distributed and adhered to by all on site contractors and service providers. The detailed preparation of a TMP, with direct implementation of procedures identified in the approved plan is critical to ensuring the safety and synchronisation of all road users, site workers, and adjacent residents. This comprehensive TMP is completed by a reputable and appropriately qualified local contractor and developed for each operation throughout a season as required. Before operations, meetings are held with the NT Department of Transport – Transport Infrastructure Planning Division for the consent of the use of highways and crossings, a Traffic Management Plan and rehabilitation protocol. This includes use of the Stuart Highway and Western Creek Road.

Across the NT, the most common form of transport of regional industry goods (fuel, cattle, gravel etc.) is road trains. These road trains and other heavy vehicles require more space on the road and take longer to stop. Pangaea understands the important role road trains play for regional NT industry, and have worked closely with local stakeholders to work with and better understand local, regional, and state-wide traffic operations. In the NT, 65% of registered articulated trucks are greater than 100 tonnes (ABS, 2016) - the largest classification of articulated trucks. Overall articulated truck involvement in the NT accounted for five fatalities, approximately 11.1% of total fatalities in 2016. Of note during Pangaea's 2014 operations, a local Pastoralist known to Pangaea lost a full road train, double stacked of cattle when the truck rolled on the Stuart Highway causing a significant local economic and social impact.

In order to better manage traffic across all states of exploration and development, Pangaea has worked with Genesee & Wyoming Australia (GWA) to take advantage of the full gauge (wide track) 3000km railway line, which runs directly through EP 167 and EP 168. The GWA Adelaide-to-Darwin service operates intermodal freight terminals in Darwin, Katherine and Tennant Creek and has access to terminals in Alice Springs. Currently, the service operates one per day, six days a week, at 50% capacity. GWA has extensive experience with oil and gas and cross industry operations, and is a proven provider in the North American shale gas industry.

In the case that Pangaea proceeds with a large scale development of the Beetaloo Sub-basin, it is expected that road traffic would increase. However, with the installation of a local rail siding, Pangaea expects the risks of road safety, potential for spills, and issue of amenity for road users in general to be substantially reduced. A railroad siding within the Beetaloo Sub-basin would be an ideal location for the cost-effective transport of regional supplies and exports. This could include gas industry supplies such as casing, drilling mud, cement components and stimulation proppant. Exports could include products such as natural gas liquids (NGLs) and condensates. A shared multi user facility would also provide opportunity to local and regional business to reduce their reliance on road trains. For example, the import of general consumables, feed, diesel, and the export of cattle (pastoral), zinc and lead (mining).

Public Health

Pangaea has maintained a consistent view that the Schedule of Onshore Petroleum Exploration and Production Requirements 2016 and the Petroleum (Environment) Regulations 2016 provide a sound basis from which to further enhance the delivery of an Environmental (and Social) Management Plan to ensure that the risk and mitigation of impact to the social environment is incorporated with the current analysis applied to the physical environment. It is Pangaea's view that the level of effort and attention to detail that currently goes into the preparation of an EMP prior to the commencement of operations for the year ahead, if applied with coverage of social impact considerations – such as engagement with Traditional Owners, local communities and Pastoralists – is more than sufficient to ensure that best practice is achieved and retained throughout production.

It would be expected that a new EMP would be produced whenever a substantial change to the situation occurs, such as a change in operational phase, location or type of activity conducted. The incorporation of human health risk (identified in the existing Regulations as impacts on health and wellbeing of affected stakeholder) is an important, heavily weighted yet inclusive component of an overarching risk assessment that already looks at many risks to the broader physical and social environment. Pangaea believes that the assessment of any given risk should not be conducted in isolation but as part of a holistic view of protection of any vulnerable elements present within the operating environment, enforced through appropriate regulation.

Conclusion

The key to a successful onshore gas industry in the Northern Territory, from Pangaea's point of view, is the generation of employment across many enabling industries over the lifecycle of the development and production phases lasting more than 20 years. Avoiding boom/bust cycles through sustainable business practice that enhances growth and shares success with the inter-connected cattle, mining, power and even defence industries (including all of the associated and very important small businesses in the local area) is critical.

Doing so with a genuine view to improve the quality of life for the local communities, Territory businesses, Pastoralists and Traditional Owners by actively engaging with them through appraisal, development and production, and over the length of decades into rehabilitation is the only way to gain and retain trust and acceptance. What occurs below the ground has no meaning without the support of those above the ground - the value extracted from below the ground is intrinsically nested in improving the quality of life for those above the ground.

Pangaea believes that with best practice regulation, a common sense approach to working with affected stakeholders and an informed community - the 'NT Way' approach - a world class gas industry can be developed that achieves the outcomes sought in retaining effective pairing of economic and social benefit. It is the development of this sizable scalable asset, safely and sustainably, through application of leading technical practices and continued innovation applied to local settings that will gain the Industry a social licence to operate over many decades, to the benefit of all Territorians.

Pangaea would like to thank the Inquiry for the opportunity to address issues raised in the Interim Report and would be happy to provide submissions on any other matters necessary to further assist the Inquiry; including a dedicated presentation to the Inquiry on the existence of current social license to operate with all of Pangaea's Northern Territory stakeholders if this would be considered useful. Attachment 1 to Pangaea Information Request Response

