

Onshore Petroleum Activity – NT EPA Advice

ENVIRONMENT MANAGEMENT PLAN – ORIGIN ENERGY LTD, BEETALOO BASIN 2019 – 2024 DRILLING, HYDRAULIC FRACTURE STIMULATION AND WELL TESTING PROGRAM EXPLORATION PERMIT (EP) 117 N2

BACKGROUND

The Minister for Environment and Natural Resources has formally requested under section 29B of the Northern Territory Environment Protection Authority Act 2012 (NT EPA Act) that the Northern Territory Environment Protection Authority (NT EPA) provide advice on all Environment Management Plans (EMPs) received under the Petroleum (Environment) Regulations 2016.

That advice must include a recommendation on whether the EMP should be approved or not, supported by a detailed justification that considers:

- whether the EMP is appropriate for the nature and scale of the regulated activity to which the EMP relates (regulation 9(1)(b))
- whether the EMP demonstrates that the activity will be carried out in a manner by which the environmental impacts and environmental risks of the activity will be reduced to a level that is as low as reasonably practicable and acceptable (regulation 9(1)(c))
- the principles of ecologically sustainable development (regulation 9(2)(a)), and
- any relevant matters raised through the public submission process

In providing that advice, the NT EPA Act provides that the NT EPA may also have regard to any other matters it considers relevant.

ACTIVITY

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| Interest Holder | Origin Energy Limited |
| Petroleum interest(s) | Exploration Permit 117 N2 |
| Environment Management Plan (EMP) title | Beetaloo Basin 2019 – 2024 Drilling, Stimulation and Well Testing Program NT Exploration Permit (EP) 117 N2 |
| EMP document reference | NT-2050-15-MP-025 Rev 1 dated 5 August 2019 |
| Regulated activity | This EMP covers the activities required to enable Origin to drill, hydraulic fracture (stimulate), test, maintain and decommission a horizontal petroleum exploration well within the 2019 – 2024 period. This includes all ancillary activities required to undertake the exploration activities proposed under this plan. The program occurs at one well location (N2-1) on the Kyalla EP117 N2 lease pad/site, and includes the following exploration well activities: drilling, hydraulic fracture stimulation, completion and workover maintenance, well testing, well suspension and decommissioning, construction and operation of a temporary camp, installation of up to two water extraction bores, routine maintenance and |

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| | monitoring activities, minor ancillary works associated with the above activities |
| Public consultation | Public consultation on the EMP was required under 8A(1)(b) of the Petroleum (Environment) Regulations as the EMP proposes the drilling and hydraulic fracturing of a well. The EMP was made available for public comment for a period of 28 days from 3 May 2019 – 30 May 2019. |

NT EPA ADVICE

1. Is the EMP appropriate for the nature and scale of the regulated activity (regulation 9(1)(b))

The technical works program includes the drilling, hydraulic fracture stimulation and well testing of one vertical pilot and horizontal petroleum exploration well at the Kyalla well site (N2-1). The well is planned to be drilled in 2019 with finalisation of the well testing activities in December 2020. On completion of well evaluation, the well will either be suspended for future re-entry, suspended on build-up or decommissioned with permanent cement plugs, in accordance with the requirements outlined in the Code of Practice: Onshore Petroleum Activities in the Northern Territory (the Code). Decommissioning and rehabilitation are planned for December 2024. The NT EPA recommends the development of a comprehensive and progressive rehabilitation plan, to minimise the risk of contamination and return the disturbed land to provide an environment similar to the original conditions.

The target formation, the lower Kyalla Shale Source Rock (SSR), lies approximately 1,420 m below the Gum Ridge Aquifer. The vertical pilot section of the well will reach an approximate depth of -1,875 m before being plugged back with cement to a kick-off point (KOP) for drilling of a horizontal section of the well. The total depth for the production hole section is likely to be reached at approximately 2,000 m below the surface and extend up to 3,000 m laterally within the reservoir.

A number of well evaluation techniques will be conducted during and/or on completion of drilling and hydraulic fracture stimulation. Key information and data required across the phases of well construction and development are outlined below:

- 1) *Basis of well design*: Critical inputs include identification of downhole formations that need to be isolated (i.e. aquifers) or hydrocarbon-bearing zones that could be encountered during drilling operations; the subsurface well objective (production and / or reservoir evaluation); the fracture gradient, which describes how much pressure is required to fracture a specific formation; pore pressure, which is the in-situ fluid pressure within a reservoir; other conditions that may affect the integrity of the well (formation fluid composition, stress regime etc).
- 2) *Drilling*: Comprises three casing strings, each cemented in place to isolate and seal-off the shallow aquifers from the rest of the well bore, to prevent fluid crossflow between formations (Figure 1).¹ A number of well evaluation techniques will be conducted during and/or on completion of drilling at the well site including mudlogging, logging while drilling, wireline logging, formation testing, core acquisition and fluid sampling.
- 3) *Diagnostic Fracture Injection Testing (DFIT)*: A DFIT is conducted once the well is complete and the overall integrity of the well has been confirmed. This test involves injecting small volumes (<10,000 L) of water, with salts (mostly NaCl) and biocide, into the formation to create small fractures, allowing the resulting pressure to fall naturally. Proppant (sand) is not used during the DFIT; hence the fracture relaxes and closes naturally when the pressure is released. The pressure decline is monitored onsite and data is analysed to assist

¹ Note production casing shown in Figure 1 is vertical, whereas for this well the production casing will be horizontal.

reservoir characterisation and subsequent modelling of the hydraulic fracturing operation. The purpose of a DFIT is to obtain information on reservoir properties to help determine subsequent hydraulic fracture design parameters in a reservoir modelling process. Modelling is completed prior to the commencement of hydraulic fracture stimulation activities to establish the stimulation fluid mixture and pumping schedule necessary to propagate the fracture network so that it is contained within the target reservoir.

- 4) *Hydraulic fracture stimulation:* This will involve perforating the 5 ½” steel casing horizontal section of the well in a series up to 20 stages, commencing at the end of the horizontal section of the well, and pressure pumping a slurry, primarily consisting of water and sand (proppant), plus a small percentage of chemicals, at high pressure through the perforated well bore into the target section of the reservoir approximately 2,000 m below ground level. Typically, 95% or higher of the total volume in hydraulic fracture stimulation fluids is a combination of fresh water and sand, with the remainder of approximately 1% as fluid-conditioning additive chemicals. Each stage will be plugged in the well bore prior to perforation and pumping of the subsequent stage. Each stage is anticipated to take 1 day.
- 5) *Well completion and test program:* Following completion of the hydraulic fracturing operation the equipment for hydraulic fracturing will be demobilised and a smaller completion rig will be brought to the well site. A production wellhead will be installed. Flowback is then initiated. In the early stages of flowback some of the water (~30%) that was pumped into the reservoir is expected to be returned to surface together with brine from the host reservoir. Subsequently hydrocarbons are expected to flow from the reservoir. The test program will consist of characterising and measuring the gas and liquid hydrocarbon production. The well testing program may continue until December 2020. The well will be suspended on completion of the test program.

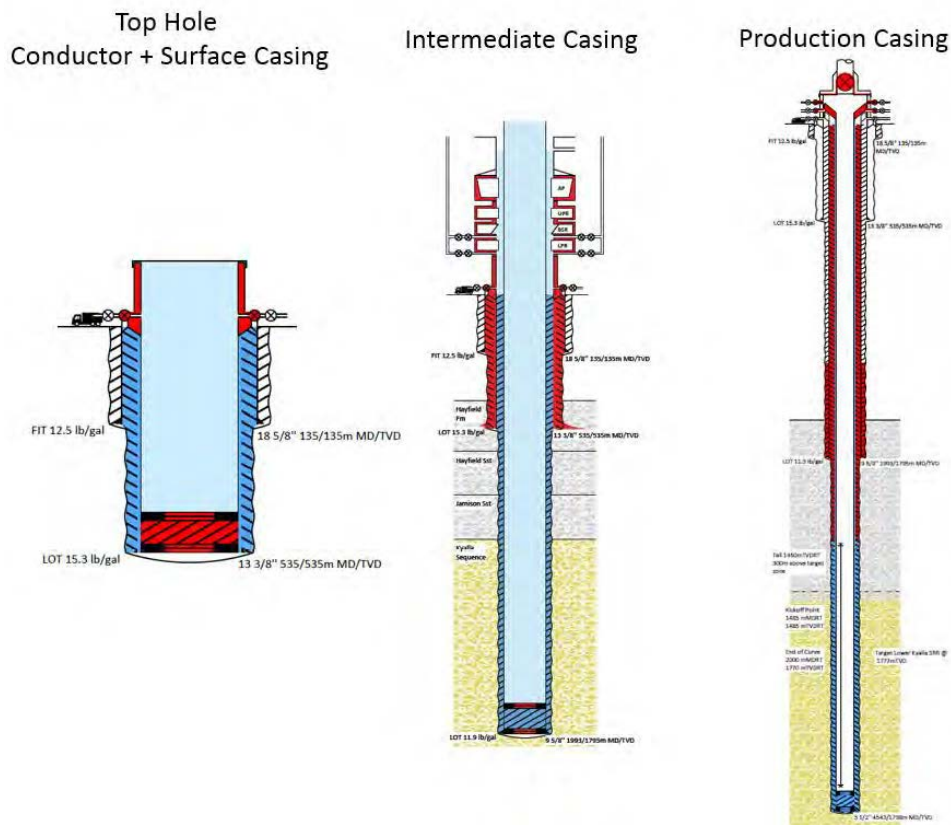


Figure 1: Example of surface, intermediate and production casing strings (Origin 2019)

The NT EPA recommends the Interest Holder provide to DENR a cementing report for the 13-3/8” steel conductor casing through the aquifers.

Estimations of consumables (e.g. water, sand and chemical additives) discussed in the EMP are based on a maximum 20 stage hydraulic fracturing program. Water and sand make up the bulk of the materials of the hydraulic fracturing fluids per stage; approximately 1.3 megalitres (ML) and 180 tonnes, respectively. The Interest Holder has estimated up to 750 m³ of drilling material, primarily comprised of drill cuttings and drilling mud, may be generated at the well site. Total volume of flowback from well hydraulic fracture stimulation required for offsite disposal is estimated to be 3.6 ML (after evaporation).

The duration of the drilling, hydraulic fracture stimulation and testing activities is expected to be approximately 18 months commencing in the second half of 2019 through to December 2020 (indicative). On completion of exploration well drilling and technical evaluation the exploration well will either be suspended for future re-entry, or in a non-success case, a decision made to decommission the exploration well with permanent cement plugs in accordance with the Code.

A temporary 40 – 60 person camp site will be established at the well site for the drilling and hydraulic fracture stimulation stages of the activity. A smaller camp will be required during the longer well completion and testing stage. Approximately 38 ML of groundwater will be sourced from existing bores in accordance with a water extraction licence granted under the Water Act 1992. The traffic impact assessment indicates additional peak project vehicle movement is 44 vehicles per day in addition to the existing peak dry season traffic volumes of 827 vehicles/day, resulting in an additional 1.2% of large combination vehicles when compared to the total volume composition.

Information relating to the nature and scale of the regulated activity is provided in the EMP in a clear format. The drilling and hydraulic fracturing works, including methane emissions monitoring are clearly described in the EMP. The stratigraphic formations intersected by the petroleum well have been adequately described; informed by more than 9,500 km of 2D data used to screen for large scale, regional faults or structures prior to the finalisation of any exploration well location. Current data of the broader Beetaloo exploration area indicates there are very few major faults present and that the strata within the Basin (i.e. away from the steep flanks) are relatively gently dipping. In addition, information gained from stratigraphic bore holes that have been drilled in the region to the base of the regional Cambrian Limestone Aquifer (CLA) system is provided in the EMP to inform planning and design of petroleum exploration well construction to isolate and protect the regional aquifer.

The existing environment has been adequately described through baseline surveys including groundwater quality characterisation at the site and is suitably understood. The EMP includes an impact and risk assessment based on information gathered during environmental baseline surveys from 2004 to 2018, previous exploration experience of the Interest Holder in EP98, and acquisition and analysis of local seismic, stratigraphic, geological and petrophysical subsurface data including an assessment of potential subsurface geohazards (e.g. faults and hazardous gases). The potential impacts and risks of the regulated activity have been identified and relevant environmental outcomes, performance standards and measurement criteria have been provided in the EMP.

The EMP demonstrates how the Interest Holder will comply with relevant requirements of the Code in undertaking this regulated activity. This includes a list of applicable ISO/API standards that have been adopted for the selection of materials for use in EP117 N2-1 well construction; drilling program environmental controls and related engineering controls contained in the Well Operations Management Plan (WOMP); a summary of which was provided in the EMP. The risk assessment provided in the EMP cross references relevant sections of the Code that apply to the mitigation and management measures to enable the reviewer to identify and confirm that the proposed drilling program activities comply with the Code. The EMP provides a Wastewater Management Plan and Spill Management Plan, Emergency Response Plan, specific petroleum well integrity criteria and monitoring programs that meet the requirements of the Code.

The level of detail and quality of information provided in the EMP is sufficient to inform the evaluation and assessment of potential environmental impacts and risks, and meets the EMP approval criteria under Regulation 9(1)(b).

2. Principles of ecologically sustainable development (regulation 9(2)(a))

Conservation of biological diversity and ecological integrity

The potential impacts and risks to threatened flora and fauna species from clearing were assessed in the EMP for the Origin Kyalla Civil Construction EP117 N2, approved 6 June 2019. That EMP identified 20 listed threatened species as likely to occur on EP117, based on availability of suitable habitat. Of these, three species were considered to have a 'medium' likelihood of occurrence. The Kyalla Civil Construction EMP outlined mitigation measures associated with construction activities to minimise impacts on threatened species and on affected environmental values including the management of threatening processes such as weeds and fire. The NT EPA advised that it considered the conservation of biological diversity and integrity of threatened species would be maintained.

Threatened species such as the Gouldian Finch and Mertens' Water Monitor were found to have more specific habitat requirements that are not present at this well site. The proposed drilling activities do not pose a significant risk to threatened species or significant habitats and vegetation types.

This EMP identifies other potential impacts and risks to biodiversity arising from vehicle strike, habitat loss/increased weeds, and ingestion of contaminated water generated during the activity. Adequate avoidance and mitigation measures are proposed to reduce these potential impacts and risks to levels as low as reasonably practicable. These include driving only on permitted designated access roads, complying with speed limits, covered tanks to store wastewater during the wet season; and implementation of a Spill Management Plan.

The potential impacts and risks of the activity identified in the EMP relate primarily to animal welfare and do not pose a significant risk to threatened species at a population level due to the low likelihood of threatened species inhabiting the area and implementation of control measures to avoid impacts to fauna. The EMP outlines measures to minimise impacts on fauna, including control measures to prevent interactions of fauna and stock with open wastewater storage tanks and the drill cuttings sump. The Interest Holder will undertake daily monitoring of the open drill cuttings sump and water storage dams, and associated fencing, for the duration of the activity. Inspection records of the daily checks will be kept. Additional contingency measures may be required if incident reporting shows impacts to fauna are greater than expected such as additional monitoring using fauna cameras and flagging, netting, screening or other measures to deter entry by birds and fauna. After completion of the drilling and hydraulic fracture stimulation operations, the open sump will be closed out, permanently removing the risk of fauna accessing the sump.

Cumulative impacts to flora and fauna from the regulated activity and the approved civil activities are not considered to be significant. The NT EPA considers that implementation of the EMP for the regulated activity will ensure the conservation of biological diversity and ecological integrity.

Integration of long-term and short-term economic, environmental, social and equitable considerations

The regulated activity has considered environmental controls in well design that ensures well integrity and long term protection of aquifers. These controls, including site-specific well integrity monitoring are appropriately identified and will be implemented in the Well Operations Management Plan (WOMP).

The regulated activity is low impact, small scale and has a duration of intensive activity of 18 months, which includes well operation/continuous flowback recovery to remove hydraulic fracture stimulation fluid and test gas production (flaring). It forms one component of a broader exploration program to inform the Interest Holder on the potential for commercial gas production in the Beetaloo Basin. Cumulative estimated volumes of groundwater extraction and

greenhouse gas (GHG) emissions from the regulated activity and approved civils and seismic activities have been included in the EMP.

A groundwater extraction licence has been granted to the Interest Holder for 175 ML per year for 3 years from May 2019 to December 2023. The total volume of groundwater to be extracted is within this volume. Groundwater extraction is informed by the NT Water Allocation Planning Framework, which indicates the volume of groundwater held in storage in the Gum Ridge aquifer is estimated to range from 1,766,000 GL to 3,532,000 GL. The Framework states the total extraction over the period of at least 100 years should not exceed approximately 1,412,800 – 2,825,600 GL. Cumulative groundwater extraction from the Gum Ridge Aquifer from May 2019 to December 2023 is approximately 1,4920 ML, significantly less than the estimated water available for extraction under the framework. The Interest Holder's licence allocation is less than 0.01%.

There is limited demand for groundwater for domestic water. Approximately 300 ML of water per year is estimated for domestic water use including 100 ML for 26 homesteads and 200 ML from the Gum Ridge Aquifer for the township of Elliott. Due to the remote location and pastoral land use in the area, future domestic demand is unlikely to change significantly.

The Interest Holder has calculated the total GHG emissions generated for the duration of the activity (drilling, hydraulic fracture stimulation and well testing) to be approximately 76,500 tCO₂e (tonnes of carbon dioxide equivalent); assuming a worst case well testing period of 12 months. Total emissions represent less than 0.5% of annual NT GHG emissions.²

Standard GHG mitigation measures outlined in the Code such as combustion flaring will be implemented. Combustion flaring is expected to reduce the emissions by approximately 85% compared to venting. Other mitigation measures include:

- measurement of the amount of gas and condensate disposed to flare using flow meters compliant with the National Greenhouse Energy Reporting Scheme (NGERS)
- six monthly leak detection on the well head (Christmas tree)
- ongoing emissions reporting compliant with NGERS
- compliance with the methane emissions monitoring program, provided as Appendix L to the EMP, including routine well head maintenance to mitigate unplanned methane emissions and leaks from well heads

Combined emissions from the Kyalla civils, and the drilling, hydraulic fracture stimulation and well testing activities described in this EMP are approximately 77,000 tCO₂e. The NT EPA does not consider cumulative greenhouse gas emissions to be significant when compared to NT and Australian emission levels. The NT EPA recommends that a mass balance for methane emissions be developed and provided to DENR that includes the volume directly vented as methane (i.e. the estimated methane discharged but not burnt).

Due to the different nature of the proposed activity compared to the civil construction activities, no further cumulative impacts are expected. In EMPs for subsequent stages (if they proceed) the Interest Holder will need to address ongoing cumulative impacts.

The EMP adequately assesses the environmental impacts and risks associated with the regulated activity and outlines appropriate avoidance and mitigation measures. This includes the assessment and management of social impacts and risks, including the appropriate management of cultural heritage. The Interest Holder has demonstrated ongoing stakeholder engagement in the EMP as required by the Regulations with landholders and land managers, traditional owners, the Northern Land Council (NLC) and NT Government Agencies.

² NT and Australian GHG emissions in 2017 were approximately 16.5 million tonnes and 535 million tonnes, respectively, as reported in the DOEE (2019) *State and Territory Greenhouse Gas Inventories 2017*. <http://www.environment.gov.au/system/files/resources/917a98ab-85cd-45e4-ae7a-bcd1b914cfb2/files/state-territory-inventories-2017.pdf>

The regulated activity will be subject to requirements of an Aboriginal Areas Protection Authority Certificate.

There are no significant economic, environmental, equitable adverse effects from the regulated activity.

Precautionary principle

The NT EPA considers there is a low threat of serious or irreversible damage from the regulated activity.

The Interest Holder's investigations into the physical, biological and cultural environment provide a satisfactory scientific basis to assess potential environmental impacts and risks, and to identify measures to avoid or minimise those impacts and risks and address scientific uncertainty. The risks are well understood and there are internationally recognised standards and established management measures in well design, operation and well integrity monitoring to ensure aquifer protection; these are reflected in the mandatory requirements of the Code.

The NT EPA is of the view that the precautionary principle has been considered in assessing the regulated activity and has not been triggered due to the low threat of serious or irreversible damage existing and the presence of a satisfactory scientific basis to assess potential impacts and risks.

Principle of inter-generational equity

The potential environmental impacts and risks associated with the regulated activity can be adequately avoided or managed through the management measures and monitoring programs proposed in the EMP. The NT EPA considers that environmental values will be protected in the short and long term and that the health, diversity and productivity of the environment will be maintained for the benefit of future generations.

The NT EPA considers the estimated cumulative GHG emissions of 77,000 tCO₂e associated with the activity are minimal in the context of annual Northern Territory and national emissions, and potential impacts on the environment are not significant.

As stated previously, the Interest Holder's water licence allocation is less than less than 0.01% of cumulative current groundwater extraction from the Gum Ridge Aquifer.

The regulated activity will be subject to requirements of an Aboriginal Areas Protection Authority Certificate. Appropriate measures are proposed for the management of items of heritage value should they be discovered.

Promotion of improved valuation, pricing and incentive mechanisms

The Interest Holder would be required to prevent, manage, mitigate and make good any contamination or pollution arising from the regulated activity, including contamination of soils, groundwater and surface waters through accidental spills.

All stages of the regulated activity, including progressive rehabilitation of all disturbed areas to an acceptable standard, would be at the cost of the Interest Holder.

The Interest Holder will be required to provide an adequate environmental rehabilitation security to indemnify the NT government.

3. Relevant matters raised through public submissions

The Proposal includes the drilling of a petroleum exploration well, and in accordance with the Petroleum (Environment) Regulations 2016, the EMP was made available for public comment for a period of 28 days from 3 – 30 May 2019. During the public comment phase, the Department

of Environment and Natural Resources (DENR) received 6,311 submissions, consisting of 6,284 submissions (form letters) via internet campaigns and 27 submissions via the advertised DENR public engagement modes. Submissions were received from community members, business entities and non-government organisations.

The majority of submissions (>90%) were opposed to onshore gas development and raised similar issues to those considered during the *Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Reservoirs in the Northern Territory* (HFI) and subsequently being addressed through NT government implementation of the 135 HFI recommendations. This NT EPA advice draws on the EMP and the findings of the HFI in assessing the concerns raised by the public.

Public submissions covered a range of social, environmental and regulatory issues (Table 1).

Table 1: Issues raised in public submissions

| Theme | Issue |
|---------------------------|---|
| Regulation and compliance | <ul style="list-style-type: none"> • quality of NT Government implementation of regulatory reforms, in particular approval of EMPs without finalisation of the Code, amendments to the Water Act 1992 and appended Well Operations Management Plan (WOMP) • application of the principles of Ecologically Sustainable Development (ESD), including the Precautionary Principle • lack of assessment of cumulative impacts in accordance with HFI recommendation 14.21 • use of open tanks is inconsistent with HFI recommendation 7.12 and poses a risk to downstream aquatic environments • economic viability of the industry, including cost benefit analysis, maximising opportunities for Territory businesses, economic baseline studies and gas exports • definition of a regulated activity as it applies to this EMP • transportation of toxic waste interstate, as opposed to treatment options in the NT |
| Social | <ul style="list-style-type: none"> • adequacy of stakeholder engagement with neighbouring and downstream landholders, potentially affected business operators, affected Aboriginal communities • lack of social licence in the NT for onshore shale oil and gas fracking • worker health during times of high seasonal temperatures • impacts to public and tourism from increased traffic |
| Chemicals | <ul style="list-style-type: none"> • toxicity and harmfulness of chemicals • adequacy of the chemical risk assessment to protect the community |
| Water | <p>Surface water</p> <ul style="list-style-type: none"> • potential impacts to downstream wetlands (e.g. Lake Woods) from spills and/or loss of containment, particularly during the wet season <p>Groundwater</p> <ul style="list-style-type: none"> • Bukalara Aquifer is not included as an aquifer that Origin will ensure is protected from mixing with other aquifers • impacts to groundwater sources for local communities, which could be vulnerable to contamination from hydraulic fracturing fluids via porous and fractured limestone aquifers • scarcity of the groundwater resource and impacts of the industry groundwater use on the resource • lack of information on monitoring of fracture distances and potential groundwater contamination from hydraulic fracturing fluids • implications of low estimated flowback volumes of hydraulic fracturing fluids • lack of information regarding radon decay products |

| Theme | Issue |
|-------------------------------|--|
| | <p>Hydrogeology</p> <ul style="list-style-type: none"> inadequate understanding of the hydrogeology of the NT potential for hydraulic fracturing fluids to contaminate aquifers via faults and fractures |
| Flora and fauna / environment | <p>Animal welfare</p> <ul style="list-style-type: none"> fauna entrapment in sumps/tanks or ingestion of contaminated water/materials collected during drilling and hydraulic fracture stimulation deleterious impacts of land and/or water contamination on fauna in general, and threatened species – e.g. Gouldian Finch, species of Varanid and migratory birds known to frequent the region – i.e. Lake Woods spread of weeds, feral pests (e.g. cane toads due to accessibility to wastewater tanks) and fire <p>Baseline studies</p> <ul style="list-style-type: none"> lack of comprehensive environmental baseline studies to demonstrate the level of impact that may be incurred by development of the onshore gas industry, including consideration of impacts to groundwater dependent ecosystems <p>Habitat degradation</p> <ul style="list-style-type: none"> increase in the spread of weeds; seeking commitment to eradicate declared and non-declared weeds introduced by this activity increased bushfires exacerbated by gas flaring or other sources loss and/or fragmentation of habitat for wildlife and livestock small areas of land clearing will contribute to the ongoing modification of the native vegetation of the Beetaloo Basin |
| Climate change | <ul style="list-style-type: none"> development of an industry that will result in increased GHG emissions and contribute to Australia's impact on climate change the EMP does not propose offsets emission offsets as per HFI recommendation 9.8, or consider scope 3 GHG emissions hydraulic fracturing may lead to undetected methane leaks occurring |
| Construction materials | <ul style="list-style-type: none"> sourcing of proppant sand structural integrity of construction materials to withstand excessive heat or flooding |

A response to the above matters raised through public submissions is provided below:

Regulation and Compliance

The Code has been finalised and is available on the DENR website. Industry and the community have been engaged in all aspects of Code implementation and subsequent mandatory requirements. The EMP has been updated to comply with any amendments to the finalised Code arising from the draft Code public consultation process.

Amendments were made to the Water Act 1992 so that petroleum activities require water extraction licences under the Act, to safeguard water and the environment. A water extraction licence for 175 megalitres (ML) per annum has been granted to the Proponent. All bores used for the regulated activities must be metered and reported.

The WOMP is a specialised engineering management plan that must be prepared and submitted for approval by well engineers of the Department of Primary Industry and Resources (DPIR). Key elements of the WOMP to ensure ongoing environmental protection of aquifers are included in the EMP risk mitigation and monitoring measures.

As outlined in the EMP, the estimated residual volume of wastewater (3.6 ML) will be transported offsite to an interstate treatment facility. Proposed water management on site involves the use of three above ground enclosed tanks of 3.5 ML capacity each and one 2.9 ML above ground open evaporation tank to reduce the amount of wastewater required to be disposed of off-site and the subsequent impacts of transporting large volumes offsite. This is necessary during the early stages of exploration when onsite treatment and recycling is unfeasible. All flowback fluid will be transferred to enclosed / covered tanks within 72-hours when a significant rainfall event is predicted.

ESD

The NT EPA's assessment of this EMP, its potential impacts (positive and negative) and the management measures used to enhance positive and reduce negative impacts has considered the ESD principles. Exploration activities are necessary to enable commercial appraisal of resources. In the absence of reliable data regarding the shale resource, exploration will take a number of years to complete, in order to assess the viability of the resource prior to production. Ongoing design, development and implementation of management and monitoring programs by the Interest Holder, should all aim to meet the objectives of ESD.

Industry viability

An economic impact assessment was completed as a component of the HFI illustrating the potential economic upsides and downsides in the event of small, medium and large scale shale gas industry developments in the NT, and the flow on effects to the rest of the Australian economy. The assessment was based on five scenarios ranging from no hydraulic fracturing through to large scale development, targeting production of 1,000 TJ/day.

The HFI also included economic modelling completed by ACIL Allen. The economic impact assessment modelling suggests that there will be limited impact on sectors outside of any onshore shale gas industry and its supply chain. Additional revenue accruing to the NT Government over the 25-year modelled period under four development scenarios where gas production occurs is between \$757 million and \$3.72 billion.

HFI recommendations such as mapping the existing service and supply industry capabilities to identify opportunities that will stem from industry growth via the Industry Capability Network (ICN) Gateway will also increase regional economic benefits long term. The target completion date for this action is end December 2021, in line with a potential decision point for industry to move beyond early stages of exploration.

Definition of a regulated activity

Regulation 5(1) defines a regulated activity as: "... an activity or a stage of any activity." The regulations do not prevent an Interest Holder from combining separate plans for different regulated activities in one document, nor does it preclude the Interest Holder submitting separate plans for different regulated activities.

Social

Stakeholder Engagement

The Interest Holder has undertaken stakeholder engagement with NT Government, landholders and land managers, traditional owners, the Northern Land Council (NLC) and the Aboriginal Areas Protection Authority (AAPA). The EMP sets out stakeholder engagement summarising the method of contact and matters raised during consultation with land owners in the vicinity of the Proposal.

Stakeholder engagement has been undertaken in accordance with:

- a) section 41(6) of the Aboriginal Land Rights (Northern Territory) Act 1976, when supplying information to Native Title holders for the purposes of negotiating an onshore gas exploration agreement
- b) clause 7 of the Petroleum (Environment) Regulations 2016, during the preparation of an EMP, which outlines the minimum requirements that an Interest Holder must meet when undertaking stakeholder engagement

- c) clause 9 of the Petroleum (Environment) Regulations 2016, which requires the EMP to include an Authority Certificate in accordance with section 3 of the Northern Territory Aboriginal Sacred Sites Act 1984

Engagement with traditional owners is co-ordinated through the NLC.

Regulatory amendments to Petroleum Act 1984 and Petroleum (Environment) Regulations 2016 give open standing to challenge administrative decisions under these statutory instruments, including the approval of EMPs and petroleum exploration permits.

Worker health

Worker occupational health and safety is the most prominent aspect of petroleum industry operations. Companies engage specialist service providers with international experience in shale gas exploration and development. Material handling for hydraulic fracturing operations is automated and potential exposure pathways (e.g. inhalation) are remote. None of the hydraulic fracturing chemicals (apart from sand due to silicosis risk) are considered carcinogenic (refer to discussion in chemicals below). Mitigation of potential exposure pathways, as well as other occupational health and safety considerations for workers (e.g. heat stress) are addressed in the company and service provider's health and safety procedures. The regulated activity must also comply Work Health and Safety (National Uniform Legislation) Act 2011 which provides for a balanced and nationally consistent framework to secure the health and safety of workers and workplaces. As identified in the EMP this includes requirements for hazardous chemical assessments, hazardous chemical register, access to safety data sheets, labelling, and the use, handling, generation and storage of hazardous chemicals at a workplace.

Transportation

The Interest Holder has assessed the impacts of traffic from their activity on the existing traffic levels/flows. Additional peak project vehicle movement is 44 vehicles/day in addition to the existing peak dry season traffic volumes of 827 vehicles/day. The results demonstrate that there are minimal changes in traffic composition associated with the project, with an additional 1.2% of large combination vehicles when compared to the total volume composition. This percentage is unlikely to significantly impact upon the road's capacity and level of service.

Contaminants of potential concern in the flowback fluid (from two previously hydraulically fractured petroleum exploration wells in the Beetaloo sub-basin), due to their persistence and higher toxicity in the environment, include heavy metals (such as arsenic, cadmium, chromium and mercury), polyaromatic hydrocarbons (such as benzo-a-pyrene). These contaminants were all below limits of reporting (refer discussion in Chemicals below). The residue following evaporation of flowback fluid is considered a listed waste and therefore must be managed under listed waste provisions of the Waste Management and Pollution Control Act 1998.

Offsite (interstate) treatment is an interim solution while the NT Government works with industry to implement a long term solution to wastewater management including recycling and disposal as has been implemented in commercially producing shale gas projects in North America.

Chemicals

Submissions raised concerns about the lack of information on drilling chemicals in particular hydraulic fracturing chemicals and storage of chemicals. A full chemical risk assessment for all drilling and hydraulic fracturing chemicals was completed and documented in the EMP, in accordance with:

- NT Government, Department of Environmental and Natural Resources, Draft Guideline for the Preparation of an Environmental Management Plan under the Petroleum (Environment) Regulations, 2019
- Department of the Environment and Energy, Exposure Draft - Chemical Risk Assessment Guidance Manual: for chemicals associated with coal seam gas extraction, 2017
- National Industrial Chemicals Notification and Assessment Scheme (NICNAS), National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia, 2017
- enHealth "Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards", 2012

- National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM); Schedule B4, Site-specific health risk assessment methodology, 2013

The majority of the chemicals were identified not to be persistent and bioaccumulative and in very low concentrations.³ The flowback fluid consists chiefly of salts, metals and petroleum products (which are separated or flared) that originate in the reservoir. Management of bacteria during the well suspension phase must be undertaken in accordance with the Code. The only chemical to undergo a Tier 2 chemical risk assessment was Hydrotreated light petroleum distillate, which was classified as a bioaccumulative and toxic substance. Inorganic chemicals such as acid are quickly neutralised in the reservoir and organic chemicals (such as biocide to prevent introduction of groundwater bacteria to the petroleum reservoir) are quickly denatured at the very high temperature and pressure in the reservoir.

The chemical risk assessment also identified 18 chemicals used in the hydraulic fracture stimulation fluid that may potentially be contained in the flowback due to their volume of use and elevated concentrations that were above ecotoxicity values. These chemicals were addressed in the wastewater management and disposal program and are used for various purposes, including but not limited to: Surfactants, scale inhibitors, corrosion inhibitors, crosslinkers, and biocides. None of these chemicals were identified to be persistent and bioaccumulative and are considered to be low risk provided they are stored and managed in accordance with the requirements of the Code for management of chemicals onsite, ALARP, the Wastewater Management Plan, Spill Management Plan and disposal program.

Water

Submissions raised a broad range of concerns about potential contamination of surface and groundwater, from overland flow, fracture distances, geological faults, regional water resources; lack of baseline data; and, radon decay products.

Issues raised regarding potential overflows from open sumps and spills of contaminated water from wastewater ponds have been adequately addressed by the mitigation and management measures provided in the Wastewater Management Plan and Spill Management Plan that were developed in accordance with the Code. From a downstream surface water impact perspective, the closest major creek system to the proposal site is Newcastle Creek approximately 60 km from the proposal area. The EMP identifies a number of small ephemeral streams (Stream Order 1 and 2) located along existing access tracks. The streams are overland flow paths that only flow for a short period during the wet season. Lake Woods lies approximately 100 km south of the proposed activity. The risk of spills and/or loss of containment from the activity impacting surface water is considered to be low.

The lease pad area will be surrounded by a 1.2 m bund to contain and prevent potential overland flow of contaminants in the event of a major spill. The drill cutting and drilling mud sump is lined with a composite, 5-layer impermeable barrier that will meet the standards specified in the Code. The drill cuttings sump has a useable volume in excess of 2,400 m³ will be operated with a minimum 1.3 m freeboard to manage potential extreme early season rainfall events.

The EMP identifies wastewater as water generated mainly from drilling, hydraulic fracture stimulation, well testing, dust suppression and camps. A large proportion of the volume of wastewater generated will be evaporated during operations. At the end of operations, the remaining 3.6 ML of wastewater will be removed offsite to a licensed facility for treatment.

Flowback fluid generated during hydraulic fracturing and well testing will be held on site and involves the use of three above ground enclosed tanks of 3.5 ML capacity each and one 2.9 ML above ground open evaporation tank to reduce the amount of wastewater feasibly required to be disposed of off-site. This is necessary during the early stages of exploration when onsite treatment and recycling is unfeasible. Large pumps will be installed, capable of transferring the entire volume of a single open tank to closed tanks within eight hours. Pumping capacity is

³ By way of comparison, chlorine which is used in swimming pools and drinking water is 10 times more toxic to aquatic organisms than the most toxic chemicals assessed for these activities.

approximately 16,000 L per minute (23 ML per day). All flowback fluid will be transferred to enclosed / covered tanks within 72-hours when a significant rainfall event is predicted.

Flowback fluid that is not evaporated during operations will be stored in enclosed above-ground, double-lined tanks with leak detection. DENR reports on laboratory analysis of a suite of more than 60 analytes tested in flowback fluid from two previously hydraulically fractured petroleum exploration wells in the Beetaloo sub-basin are available at the DENR Onshore Petroleum webpage. Contaminants of potential concern in the flowback fluid, due to their persistence and higher toxicity in the environment, including heavy metals (such as arsenic, cadmium, chromium and mercury), polyaromatic hydrocarbons (such as benzo-a-pyrene) were all below limits of reporting. The results are similar to those reported in major studies of flowback from shale plays in North America (Hayes, 2009; Gandhi *et. al*, 2018)⁴. These studies concluded that spills of flowback to ground were unlikely to pose a significant risk to aquatic ecosystems provided they were contained and cleaned up promptly. The residue following evaporation of flowback fluid is considered a listed waste and therefore must be managed under listed waste provisions of the Waste Management and Pollution Control Act 1998.

Consistent with the Code, all wastewater will be treated via an evaporation tank to reduce the amount of water stored in covered tanks and the subsequent impacts of transporting large volumes offsite for treatment and disposal.

The EMP outlines a summary of specific controls identified in the Well Operations Management Plan to ensure isolation/protection of aquifers and overall petroleum well integrity is achieved. The well design and construction method described in the EMP surpasses the requirements mandated by the Code for the protection of aquifers, with multiple verified barriers that includes conducting cement bond logging and the upload on the DPIR website of a Well Barrier Integrity Validation (WBIV) report certified by an independent and reputable validator in accordance with Clause 302a of the Schedule of Onshore Petroleum Exploration and Production Requirements (2019). The WBIV must comply with the DPIR Well Barrier Integrity Validation Reporting guideline.

Bukalara Aquifer

The Bukalara Aquifer, which lies below the Gum Ridge Aquifer in this location is not intersected by any known water bores. Water quality and production are likely to be marginal based on records from previous petroleum wells drilled in the area. However, the petroleum well design has ensured that the Bukalara will be isolated from the important surficial aquifers, namely the Anthony Lagoon Aquifer and the Gum Ridge Aquifer, and the deeper hydrocarbon zone by means of 3 well barriers (namely the surface, intermediate and production steel casing and associated annulus cementing) which exceeds the requirements in the Code. The surface casing will extend down below the Bukalara Aquifer to the Hayfield formation which is a mudstone aquitard thus ensuring isolation from deeper hydrocarbon bearing formations. The base of the Bukalara Aquifer is separated from the target hydrocarbon formation for hydraulic fracturing by more than twice the internationally accepted required minimum vertical separation distance of 600 m required by the Code, including a number of thick aquitards, thus ensuring that hydraulic fractures cannot intercept the aquifer, which is over 1 km above the shale gas resource.

Contamination of groundwater from hydraulic fracturing fluids

All drilling and hydraulic fracture stimulation activities will be undertaken in accordance with the Code, including the preparation of a WOMP that requires approval from DPIR, prior to these activities commencing. Strict well construction and well integrity practices are mandated in the Code to mitigate potential impacts from drilling and hydraulic fracture stimulation, such as contamination to, or mixing of, groundwater aquifers, such as the Anthony Lagoon and Gum Ridge aquifers within the CLA system.

⁴ Hayes, T. 2009. *Sampling and Analysis of Water Streams Associated with the Development of Marcellus Shale Gas*, Final Report, 31 December 2009

Gandhi, H, Sadiq, R, Hu, G, and Hewage, K. 2018. Ecological Risk Assessment of Accidental Release of Flowback Water: A Conceptual Framework. *Human & Ecological Risk Assessment* 24(2): 398-426.

The exploration well will have multiple strings of steel casing with each casing string cement grouted to the surface and multiple engineered and system controls to adequately detect water quality threats to the CLA (see section 1).

In relation to hydraulic fracturing fluids recovery and contamination to groundwater, a tiered chemical risk assessment has been completed. The majority of the chemicals were identified not to be persistent and bioaccumulative and in very low concentrations.

Additional mitigation measures include installation of a groundwater monitoring bore system. This consists of a control monitoring bore array, located up-gradient and within 100 m of the planned or existing location of a petroleum well pad; and an impact monitoring bore array, screened at similar depths to the control monitoring bore array, 20 m down-gradient of the location of the petroleum well. This layout enables ongoing comparison of background groundwater quality with that immediately downstream of the petroleum well. One monitoring bore is required for each discrete aquifer unit, which is screened near the top, middle and bottom of the vertical extent of that unit. In the Beetaloo Basin this may include the Anthony Lagoon aquifer unit and the important deeper regional Gum Ridge Aquifer. Water is sampled from each of these monitoring bores on a quarterly basis and analysed at a NATA accredited laboratory for an array of analytes, including Total Dissolved Solids, chloride, electrical conductivity, boron, strontium, barium, naturally occurring radionuclide material (NORM) and dissolved methane. Monitoring will continue for three years and all groundwater monitoring data will be published on the DENR website.

Industry groundwater requirements and regional water resources

Gas activities are subject to the provisions of the Water Act 1992, and water extraction will be licensed. Practices that pose an unacceptable risk to water resources, such as the use of surface water, reinjecting waste into aquifers, or allowing wastewater from hydraulic fracturing activities to come into contact with any other waters are prohibited under the Water Act 1992.

As previously discussed, an extraction licence has been approved for the proponent for 175 ML per year for 3 years from May 2019 to December 2023. Based on limited demand for groundwater for domestic water (approximately 300 ML per year), and due to the remote location and pastoral land use in the area, future domestic demand is unlikely to change significantly.

Hydraulic fracture distances

Submissions raised concerns regarding the fracture distances and potential contamination pathways. This issue was reviewed and addressed during the HFI, which found seismic surveys demonstrate that most of the Beetaloo Sub-basin contains relatively little internal faulting. The HFI also investigated the potential for migration of hydraulic fracturing fluids due to fracture outgrowth out of the production zone and through fracture intersection the geological features, such as permeable faults or pre-existing natural features:

- The likelihood of fractures growing out of the shale rock region for distances of 1,000 to 3,000 m is extremely low.
- The location of faults is taken into consideration during the design and construction of each well and the gas companies actively avoid faults because their occurrence can seriously compromise the effectiveness of the hydraulic fracturing operation, as well as being a potential environmental risk.

The CSIRO has reviewed the well barrier and well integrity failure rates reported in the open literature largely using data sets from the US, found that the rate of well integrity failures that have the potential to cause environmental contamination is in the order of 0.01%, with several studies finding no well integrity failures, while the rate for a single well barrier failure was in the order of 1 to 10%.

The Interest Holder has committed to constructing all wells to international standards required by the Code.

Results of ongoing groundwater monitoring at each well site, undertaken in accordance with the Code and Guideline, must be submitted to the DENR every quarter for three years from the approval date of the EMP. The results of the groundwater monitoring will be published on the DENR website on a quarterly basis. The baseline dataset will provide the establishment of well

site specific performance targets to assure no adverse effects on water quality. These performance targets will be established following completion of the petroleum well and published on the DENR website.

Naturally occurring radionuclide material

Naturally occurring radioactive material (NORM) such as uranium, radium, and radon and associated decay products are dissolved in very low concentrations during normal reactions between water and rock or soil. Routine assessment for presence of NORM is conducted by measuring gross alpha and gross beta concentrations measured in becquerels (Bq)/L and compared to a range of standard such as drinking water guidelines. 1 Bq is equivalent to one nuclear disintegration per second. The analytes specified in the Code for groundwater monitoring, drilling material assessment and flowback assessment includes the requirement for assessment of gross alpha and gross beta as means of detecting and evaluating NORM levels. To date, the baseline groundwater monitoring of the Gum Ridge Aquifer conducted at the proposed well site shows that gross alpha slightly exceeds (up to 4 times) the drinking water guideline of 0.5 Bq/L. This is not unusual in aquifers where concentrations of dissolved constituents can build up during prolonged periods of water/rock contact. While radon has a relatively short half-life measured in days, the decay product lead-210 has a much longer half-life because it is more stable and consequently emits orders of magnitude less radiation than radon. The NHMRC health guideline value for lead-210 in drinking water is 0.01 mg/L (10 µg/L).⁵ Groundwater monitoring of the of the Gum Ridge Aquifer conducted at the proposed well site by Origin shows that lead levels were generally less than 0.01 µg/L.

The groundwater monitoring program will continue to monitor NORM in accordance with the Code and the Preliminary Guideline: Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo Sub-basin⁶.

Flora and Fauna

Submissions raised a broad range of concerns around the use of open wastewater sumps, including:

- the potential to become a breeding ground for cane toads
- may lead to entrapment of fauna
- are sources of contaminated drinking water for birds

Other issues raised included: Insufficient environmental baseline surveys and data to support industry development; and, habitat degradation through the spread of weeds, increased sources of bushfire (e.g. flaring) and fragmentation.

Drilling fluids drawn from the well are composed primarily of cuttings and muds. The maximum total volume of drilling fluids estimated to be generated by the activity is 400 m³. As outlined in the EMP, the solid material resulting from drilling operations will be tested and a suitably qualified third party will determine whether the material is suitable to be disposed of on the lease pad using a 'mix-bury-cover' approach (as per the Code, NT Waste Management and Pollution Control Act and National Environmental Protection Site Contamination Assessment).

Potential risks to fauna from access to open sumps and wastewater tanks have been considered by the Interest Holder. Drilling sumps and wastewater tanks are located within the lease pad area, which will be fenced to prevent stock and fauna access. Sumps also include fauna ladders to minimise potential ingress. During operations, the infrastructure, which is in a high traffic area on the well site, will be monitored daily and logs kept of fauna interaction.

Wastewater tanks will not be accessible to cane toads. Moreover, based on previous flowback fluid quality analysis in the Beetaloo it is expected that the gross salinity prior to evaporation will

⁵ NHMRC, NRMCC 2011. *Australian Drinking Water Guidelines 6 National Water Quality Management Strategy*. Version 3.6 Updated August 2018. <https://www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines#block-views-block-file-attachments-content-block-1>

⁶ https://denr.nt.gov.au/_data/assets/pdf_file/0009/618957/Preliminary-Guideline-Petroleum-Well-Water-Quality-Monitoring.pdf

exceed twice the salinity of seawater. Neither cane toads nor their progeny can survive in seawater.

Management of hydraulic fracturing flowback using separators and flaring prior to discharge into open tank systems in the Beetaloo, Cooper Basin in South Australia, Western Queensland and the Kimberley, indicates that the risk to birdlife from open tank storage of hydraulic fracturing flowback fluid is considered low. As outlined previously, a tiered chemical risk assessment has been completed. The majority of the chemicals were identified not to be persistent and bioaccumulative and in very low concentrations. Interaction with birds will be monitored and contingency measure implemented if required.

Baseline surveys and environmental studies

The EMP Land Condition Assessment (EMP Appendix B) includes a review of existing data collected between 2005 and 2016, with ground-truthing of the proposed exploration areas in August 2018. The Appendix acknowledges that not all species were able to be identified due to timing of the survey; however, sufficient data was able to be captured to obtain a good understanding of the land condition within the proposed lease area and inform mitigation measures for the protection of the environment.

The LCA has been reviewed and assessed by the relevant NT Government agencies and deemed to be adequate for the potential impacts and risks to general and threatened flora and fauna. Avoidance and mitigation measures have been identified in the EMP and are adequate to reduce risks such as vehicle-strike, dust, erosion and/or spills to as low as reasonably practicable, in relation to potential impacts on biodiversity.

To strengthen terrestrial and aquatic regional knowledge, the government is working with independent experts, research agencies such as CSIRO, and industry to undertake a comprehensive Strategic Regional Environmental and Baseline Assessment (SREBA) in prospective onshore gas basins before granting any production approvals. A SREBA will provide baseline data to properly assess all the biophysical risks, allow planning to minimise the potential for cumulative impacts and provide a baseline for monitoring to ensure satisfactory environmental outcomes. It is anticipated that each SREBA will take at least three years to complete.

With respect to groundwater dependent ecosystems; groundwater discharges from the Gum Ridge Aquifer are associated with the groundwater dependent ecosystems of Bitter Springs and Rainbow Springs. Modelling undertaken by DENR concluded that the proposed extraction would have no change in reliability of spring flows to Bitter Springs or Rainbow Springs, or at indicator sites located at Eley National Park and Red Rock in the Roper River. A study by Cooke & Eamus (2018)⁷ indicates that terrestrial groundwater dependent ecosystems generally access water to depths of 15 – 20 m below ground level. The standing water level of the shallowest aquifer, the Anthony Lagoon Aquifer is measured at 64 metres below ground level at the Kyalla well site, which is outside the reaches of terrestrial groundwater dependent ecosystems.

Habitat degradation

Based on weed baseline surveys in all areas that will be disturbed, there is no evidence of weeds on access tracks, camp and lease pad areas. Origin has committed to implement a weed management plan to control weeds during construction, operation and for 3 years after completion of works. The weed management plan has been developed in accordance with the Weed Management Planning Guide: Onshore Petroleum Projects and assessed by the relevant NT Government agencies as satisfying the requirements for this EMP. Mitigation measures include inspection and cleaning of construction equipment prior to accessing the site, and onsite weed control.

From a bushfire perspective, the property falls with the Savanna Fire Management Zone. When a Fire Danger Period has been declared, no burning may take place except where a permit to burn has been obtained from a fire control officer or a fire warden. A fire management plan has been developed for EP117 as part of the EMP. The main firefighting suppressant will be water.

⁷ Cook, PG and Eamus, D (2018). The Potential for Groundwater Use by Vegetation in the Australian Arid Zone

Areas such as the camp will have hand-held fire extinguishers installed in accordance with Australian Standards and based on fire class category.

Effective fire management requires the fire management plan to be implemented, including that fire suppression equipment be available and that fire control zones, established around each of the well sites, be cleared of vegetation and maintained to limit the risk of fire spread during project activities. Interest Holders are expected to implement a range of safety measures, including establishing and maintaining a fuel free buffer around the flare and fencing the buffer area. The Interest Holder has committed to undertaking horizontal flaring into a flume and water curtain, as requested by DENR. This method reduces condensate carry-over and the potential for the flare to be a bushfire ignition source. EMPs must comply with the Code and regional management plans, developed in accordance with the Bushfires Management Act 2016.

Land clearing has been assessed previously under the Beetaloo Basin Kyalla EP117 N2 Civil Construction EMP, approved 6 June 2019. The mitigation measures described were considered to be adequate to reduce risks and potential impacts to biodiversity values to as low as reasonably practicable. Regionally, the HFI found that any onshore shale gas industry is likely to disturb a small surface area relative to the size of the NT (estimated at between 67 km² and 476 km²) compared with the NT's total land area of 1,421,000 km². This means that the impact of any onshore shale gas industry on other key NT industries is likely to be minimal in terms of land use.

Climate Change

Submissions raised concerns about cumulative impacts of the industry on NT and national GHG emissions and climate change; and methane emissions from hydraulic fracturing and/or leaks caused by well failure.

As previously discussed, the Interest Holder has calculated the total GHG emissions generated for the duration of the activity to be approximately 76,500 tCO₂e and cumulatively including Kyalla civils, to be approximately 77,000 tCO₂e. The NT EPA does not consider these emissions to be significant compared to NT and Australian levels but has recommended that a mass balance for methane emissions be developed that includes the volume directly vented as methane (i.e. the estimated methane discharged, including that emitted from the flare due to incomplete combustion).

Climate change is a global issue and the NT EPA understands the Chief Minister has written to the Prime Minister to commence discussions on ensuring no net increase in the life cycle GHG emissions in Australia from any onshore shale gas production in the NT (HFI recommendation 9.8). The NT climate change and environmental offsets policies are under development and will be progressed in parallel with the delivery of the NT Government's hydraulic fracturing Implementation Plan⁸. The target completion date for this action is end December 2021, in line with a potential decision point for industry to move beyond early stages of exploration. The NT EPA is supportive of the NT Government's commitment to developing a climate change policy.

Methane emissions/leaks

The CSIRO has undertaken a series of mobile surveys to measure methane emissions from natural and human-derived services, in the central part of the Beetaloo Sub-basin in the wet, dry and fire seasons. To date, the seasonal baseline surveys indicate a median methane value across the area of 1.81 ppm, which matches the normal background concentrations of approximately 1.8 ppm expected in rural or natural areas.

All emissions generated by the proposed activity must be reported in accordance with section D.5.9 Venting and Flaring of the Code. Emissions from exploration, well construction (including during flowback) and workovers must be measured and reports submitted. These emissions should be measured using methods consistent those specified under the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

⁸ The Implementation Plan is available at:

https://cmsexternal.nt.gov.au/_data/assets/pdf_file/0004/673123/fracking_implementation_plan.pdf

Construction Materials

Sourcing of proppant sand

The technical requirements and Quality Assurance / Quality Control for suitable proppants (e.g. sand) in hydraulic fracturing operations are very specific and require dedicated equipment and a suitable source. Interest holders will initially source the material from existing proppant suppliers outside the NT.

Structural integrity of construction materials

All of the construction materials used in the onshore gas industry must meet internationally accepted standards which are specified in the Code. The companies engaged in these operations have extensive experience in similar environments in the Cooper Basin in South Australia, Western Queensland, the Kimberley and internationally.

4. Environmental impacts and risks reduced to a level that is as low as reasonably practicable (ALARP) and acceptable (regulation 9(1)(c))

The Interest Holder has undertaken a process to avoid impacts on environmental values, informed by appropriate baseline studies and surveys and timing of the regulated activity. The timing of works will be managed to ensure the risks arising from inclement wet weather, including compliance with the Code, as a mechanism of demonstrating achievement of ALARP. An Emergency Response Plan will be implemented, which includes flood management and mitigation measures. Evacuation and site readiness protocols are incorporated in standard operating procedures, including the evacuation of non-essential personnel.

The EMP demonstrates a systematic identification and assessment of environmental impacts and risks associated with the regulated activity. The key potential environmental impacts and risks are:

- groundwater quality – a reduction in groundwater quality due to chemical spills or leaks during drilling, well construction, hydraulic fracturing and well testing activities. A reduction in groundwater quality may also occur as a result of aquifer cross-flow due to inappropriate well construction failing to isolate each of the aquifers intersected by the petroleum well
- groundwater quantity – a reduction in groundwater quantity due to groundwater extraction associated with the activities
- terrestrial environmental quality – localised contamination of soil due to inappropriate storage of drilling mud and chemicals and spill or overflow of drilling mud
- terrestrial fauna - fauna interaction with open sumps containing drilling mud or cuttings may result in disturbance, injury or death to fauna

Mitigations measures for the management of all wastewater discussed under Section 3 above, demonstrate potential impacts and risks to surface water quality from flowback fluids have been reduced to a level that is ALARP and acceptable.

Groundwater Quality

The Interest Holder has adequately identified the impacts and risks to groundwater quality and provided commitments in the EMP control measures to reduce those potential impacts and risks. These include implementing the requirements of the Code and not commencing activities until a WOMP has been approved by the regulator. The risks of chemical spills and leaks and aquifer cross flow are well known and the Interest Holder has extensive experience in drilling conventional and unconventional petroleum wells in the NT and other jurisdictions. All known controls measures for ensuring well integrity and aquifer isolation have been adopted. Ongoing groundwater monitoring at the well site, undertaken in accordance with the Code and Guideline, must be submitted to the DENR every quarter for three years from the approval date of the EMP. The results of the groundwater monitoring will be published on the DENR website on a quarterly basis. To ensure a robust groundwater quality baseline dataset, the NT EPA recommends a minimum of seven sampling events be completed from the control monitoring bores (up gradient

of the petroleum well) prior to completion of the drilling program. The baseline dataset will provide the establishment of well site specific performance targets to assure no adverse effects on water quality.

The aquifers intersected by the Kyalla petroleum well are of high environmental value. As such, there should be 'no change' to existing baseline groundwater quality, i.e. no change in the natural range of values as a result of the regulated activity. The NT EPA has recommended a condition of approval of the EMP to demonstrate 'no change' to existing groundwater at the Kyalla well site.

Groundwater Quantity

The Interest Holder has identified and addressed the potential impacts and risks to other groundwater users. Compliance with the groundwater extraction licence limits and conditions including groundwater extraction metering and limiting the volumes required for the regulated activity, reduces the risk to ALARP and to an acceptable level. The groundwater monitoring program includes ongoing groundwater level reporting at the well site. The NT EPA recommends the results of groundwater monitoring be provided every quarter for three years for publishing on the DENR website.

Terrestrial Environmental Quality

The potential impacts and risks of contamination of soil, through inappropriate storage and handling of drilling muds, chemicals and wastewater has been identified by the Interest Holder. The EMP includes commitments that include bunded and spill containment of chemicals and drilling muds and the implementation of the Wastewater Management Plan and Spill Management Plan, in accordance with the Code. The Interest Holder has not deviated from known industry codes and standards. The implementation of the Code requirements such as engineered cuttings sump with impermeable membrane, and laboratory testing of drill cuttings and residual drilling muds to determine disposal options, further reduces the risk of contamination of soil. At the completion of the drilling operations, a suitably qualified independent third party approved by DENR, as defined in Section C.4.1.2(f) of the Code, will undertake sampling for laboratory testing of drill cuttings and residual drilling muds, including leachability testing of heavy metals, NORM and other contaminants of potential concern, to determine suitability of in-situ burial.

The EMP documents how the Interest Holder will comply with the relevant mandatory requirements of the Code as a minimum best practice standard. A Wastewater Management Plan and a Spill Management Plan have been prepared that meet the requirements of the Code and include proven management practices. The NT EPA recommends that the interest holder provide a laboratory report to DENR on leachability testing of drill cuttings and drilling mud, no later than 7 days after testing.

Terrestrial Fauna

The Interest Holder has identified and addressed the potential impacts and risks to fauna with open storage of drill cuttings in an engineered sump and lined, open evaporation tanks. The Interest Holder has committed to implementing a routine monitoring program to log fauna interactions with wastewater tanks (including the area surrounding the lease pad). Where fauna interactions are identified (i.e. bird or fauna mortalities >5 individuals), additional controls such as netting or the use of other bird deterrents will be implemented.

The Interest Holder has committed to closing and rehabilitating the open sump once it is no longer required, removing the risk of fauna accessing the sump.

The NT EPA considers that all reasonably practicable measures will be used to control the environmental impacts and risks, considering the level of consequence and the resources needed to mitigate them.

The NT EPA considers that the environmental impacts and risks will be reduced to an acceptable level, considering the principles of ecologically sustainable development as discussed above, the sensitivity of the local environment, relevant standards and compliance with the Code.

5. Other relevant matters

Regulation 9 requires that an EMP provides a comprehensive description of the regulated activity, including provision of a detailed timetable for the activity. To meet this requirement, the NT EPA recommends that the Interest Holder be required to submit a detailed timetable for the regulated activity to DENR prior to approval of the EMP. The timetable should address all aspects of the activity and include, but not be limited to dates for the implementation of commitments and associated hold points. This should also include monitoring of weather conditions related to potential onset of the wet season and consequent demobilisation of the rig and ancillary infrastructure and stabilisation of the well sites. The NT EPA recommends that the timetable be updated each month or as seasonal weather forecasts emerge.

CONCLUSION

The NT EPA has reviewed the public submissions as part of its decision-making and when making recommendations to the Minister. This NT EPA advice to the Minister for Environment and Natural Resources considers and provides a response to any relevant matters raised in public submissions.

The NT EPA considers that, subject to the recommended EMP approval conditions, the EMP:

- is appropriate for the nature and scale of the regulated activity
- demonstrates that the regulated activity can be carried out in a manner that potential environmental impacts and environmental risks of the activity will be reduced to a level that is as low as reasonably practicable and acceptable.

In providing this advice the NT EPA has considered the principles of ecologically sustainable development. The NT EPA has also taken into consideration that prior to commencing well activities (including drilling), a WOMP will be prepared and approved by the DPIR.

RECOMMENDATION

The NT EPA recommends that should the EMP for Origin Energy Ltd be approved, the following conditions be considered:

Condition 1: The Interest Holder must provide a report to DENR where there is a non-compliance of an approval condition within 48 hours of becoming aware of the non-compliance.

Condition 2: The Interest Holder must provide to DENR, an updated timetable for the regulated activity prior to the commencement of the activity and provide an updated timetable to the DENR each month. The timetable must include dates for the implementation of commitments, development of key document and associated hold points.

Condition 3: The Interest Holder provide to DENR a cementing report for the steel conductor casing through the aquifers as soon as practicable but not more than seven days after completion of the cementing job for the Kyalla exploration well EP117 N2-1.

Condition 4: The Interest Holder must provide to DENR:

- i. results of ongoing groundwater monitoring in accordance with the Code and the Preliminary Guideline: Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo Sub-basin every quarter for three years from the approval date of the EMP for publishing on

- the DENR website, to inform the development of site-specific performance standards for groundwater quality
- ii. notification of any results in the inter-quartile range of monitored parameters in groundwater above the natural distribution of values that occur at the Kyalla well site within five days of discovery
 - iii. results of monitoring and reporting on the characterisation and analysis of flowback fluid in accordance with the Code, within one month of commencement of flowback for publishing on the DENR onshore petroleum webpage.

Condition 5: The Interest Holder must provide to DENR a report on the assessment and leachability testing of drill cuttings and drilling mud including the final disposal options, within three months of completion of the drilling program.

Condition 6: The Interest Holder must develop in consultation with DENR a rehabilitation plan for each disturbed areas appropriate to the nature and scale of the activity, in accordance with the requirements in the Code, no later than 3 months after commencement of the activity. The Interest Holder must undertake progressive rehabilitation of the disturbed land in accordance with the plan, to provide an environment similar to original condition and uses.

Condition 7: The Interest Holder in addition to standard NGER reporting requirements, must provide to the DENR a mass balance of actual greenhouse gas emissions that incorporates flare efficiency and by-pass calculations, including emissions directly vented as methane within six months of completion of well testing activities.

Condition 8: The Interest Holder must provide to DENR an analysis of offsite disposal and beneficial use options, other than flaring, for liquid hydrocarbons if the combustion of liquid hydrocarbons at the flare exceeds an average of 5000 litres per day during the first month or following months of flaring.



DR PAUL VOGEL AM MAICD
CHAIRMAN

NORTHERN TERRITORY ENVIRONMENT PROTECTION AUTHORITY

7 AUGUST 2019