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12th June 2017

The Hon. Justice Rachel Pepper
Hydraulic Fracturing Taskforce
GPO Box 4396
DARWIN NT 0801

Submission- Scientific Inquiry into Hydraulic Fracturing - Nutwood Downs - Beetaloo Basin.

Your Honour,

Mr Rod Dunbar, Nutwood Downs requested our input into the above review. I thank Justice Pepper in committing her time into this inquiry.

If any clarification or additional information is required please do not hesitate to contact me.

Under the current economic, legislative and regulative framework we cannot recommend that Mr Dunbar sign any access contract with Origin agreeing to the Hydraulic Fracture Stimulation (HFS) of gas bearing formations under Nutwood Downs. There is a massive negative financial and potentially disastrous environmental impact on the existing historical business operation at Nutwood Downs. Our assessment is that broad acre HFS in the Beetaloo Basin is not economically or environmentally justifiable at this time.

In relation to Australia as a whole a massive impending financial loss is imminent. The contract LNG pricing entered into by gas producers will not provide any economic benefit to Australia and the majority of Australians from "mining" these resources now. World LNG prices have collapsed, in line with linked oil pricing, to a point where we believe losses on export LNG market are occurring. A world glut is highly likely, particularly as numerous High Efficiency Coal Fired Power Stations are built in Asia and India.

Based on publically available economic evidence so far disclosed specifically beyond Australia's economic zone, it is apparent that there is no visible Australian public financial benefit, or Return on Investment (ROI) in the form of Commonwealth, State and Territory Royalties, Corporate Taxation Revenue to the Commonwealth or compensatory benefit to the landholder (landowner) and, by extension, when including many unknown future stock and domestic potable water issues and/or other unforeseen and unaccounted environmental issues, it is somewhat astounding that extensive independently commissioned Australian public cost benefit analysis have not been more forthcoming. Based on this same economic analysis beyond Australia's economic zone, it is incomprehensible that the NT Government would put at risk more valuable sustainable export industries, such as the NT Cattle industry and Tourism, for a non-existent Australian public financial benefit or ROI.

The only profit that is made is by selling gas on the local market at prices nearly double that in the United States (US)[14]. This in effect is detrimental to Australia as a whole impacting Australian businesses that must compete overseas while paying exorbitant local gas prices. These local businesses sacrifice their profits[12] so that Origin, Santos and other gas producers can remain viable, and overall the Governments of Australia make a loss, by the "mining" what would normally be an asset, because of taxation write downs and subsidies. In a place where financial reality was used, Australia should be importing LNG to supply the domestic market; or installing high efficiency coal fired power stations, and leaving shale and tight gas in the ground until at least there is an economic benefit to existing businesses on the land and Australia as a whole.

To highlight the economics that make the whole process non beneficial to Australia as a whole, one only need consider the following:-

US Thermal Coal Price	A$ 2.96/mmBTU
Break even price for LNG to Japan via Darwin [2]	A$12.06/mmBTU
Estimated Break Even price for LNG to Japan via Gladstone[6]	A$10.66/mmBTU
Estimated **original** Origin Contract price to Japan	A$16.00/mmBTU
Estimated **current** price Origin LNG Sales to Japan	A$ 7.50/mmBTU
Export LNG Price March 2017 from the United States EIA [14]	A$ 5.42/mmBTU
World Bank Forecast 2018 to 2020 LNG Price Japan	A$10.00/mmBTU
Estimated Origin Loss LNG to Japan	A$ 3.16/mmBTU
Estimated Breakeven Cost NG to Sydney[2]	A$ 7.82/mmBTU
Current Wholesale price NG Sydney	A$ 9.33/mmBTU
Estimated Profit Sydney Wholesale Market	A$ 1.51/mmBTU

With approx two thirds of Australian gas exported as LNG sales, there is a loss when considering this cost and selling price data. Currently the internal Australian natural gas sales do not make up that loss. If the World Bank is correct in there forecast there are no profits in Australia from Japanese LNG sales over the next decade.

We make our recommendations in this report because we believe, by observing recent events that the NT government has already committed itself via Corporate contracts to HFS with gas producers[4,5,7.] If the decision has already been made to proceed, my conclusion is that the inquiry may well be a waste of time; and in effect, if this is the case it is going to be very difficult to achieve the necessary changes required to resolve the looming economic loss, and the legislative and regulative issue raised by the inquiry. A Corporate contact between government and the gas producers, could in effect make any inquiry findings to no effect, irrespective of what they are, and more importantly they bypass historical law. To advise Mr Dunbar to sign any agreement with Origin removes his rights as the leaseholder, trying to pursue the Nutwood Family's long standing business enterprise at Nutwood Downs. Contracts between the NT government and gas producers, like Origin, directly impact the economics and viability of land/leaseholders and property owners in areas; where the current lease necessitates that existing inputs, including potable water and land access are a critical, and a historic requirement, to support agriculture. Potentially these critical inputs are removed without compensation or restoration by gas producers and the NT government.

The first part of the report is a summary of where we believe attention is required to modify what we see a serious shortcomings in economics, legislation, regulations, practices and oversights of the potential wide adoption of HFS gas production in the Beetaloo Basin. The second part is the detail to support the summary.

The following points assume that fracking is going ahead, based on our conclusion that it is already a fait accompli; however they should not be read as an agreement or recommendation that HFS should proceed. We believe that current economics cannot support HFS gas production in the Beetaloo Basin.

SUMMARY

A. The Northern Territory Government needs to address the following:-

i) There are massive discrepancies in the benefits/compensation offered to leaseholders/landowners and native title holders. If governments in Australia can't treat citizens equally then they actually foster racial discrimination, unrest and the future breakup of Australia. Proper compensation should be on offer for the interruption and modification of the agricultural leaseholders operation.

ii) There are substantial risks associated with unconventional gas exploration and production and at this point neither Origin or Falcon have offered to compensate, or supply the relevant insurance details to the Nutwood Downs leaseholders should there be a financial, environmental or other impact from their operations. Origins existing risk assessments, covering the initial exploration wells, does not cover the financial impact on the existing leaseholder from its proposed HFS operations. This needs to be addressed in production licences. Any acceptance by the NT government, that commercial gas extraction should proceed, without adequate insurance coverage or compulsory compensation fund by gas producers and contractors is negligent.

These risks include items like:-

- The contamination or loss of water from existing water bores which are critical to the value, production efficiency and cost of the agricultural and tourism operations and life in general in the Beetaloo Basin.
- The contamination of surface waters which are critical to the value, production efficiency and cost of the agricultural operation as well as the environmental impact of produced and waste waters on threatened bird species, e.g., the Gouldian Finch.
- Methane/Hydrogen Sulphide gas leaks contaminating potable water bores and water storage installations risking fire and human injury to leaseholders where these risks don't exist at present.
- The contamination of livestock and the subsequent meat produced from these animals.
- The reduction or destruction of the value of the property.

iii) Where leaseholders and property owners have attempted in good faith to negotiate satisfactory contracts with gas producers and have been unsuccessful, the right of a property owner/leaseholder to deny access to the HFS gas producer should be enshrined in legislation.

iv) The NT Government is abdicating its responsibilty to the NT population and property owners. The following items needs to be addressed by the NT Government urgently, before wholesale fracking occurs:-

a) The gas producer contracts offered to leaseholders recently transfer responsibilities that they have in their exploration and/or petroleum licences

to the leaseholder. Reference Mr Rod Dunbar/Lexcray Pty Ltd submission. The NT government must oversee all contracts. This is especially required if the government had already signed corporate contracts with gas producers. Gas producer trust and the social licence has already been destroyed by their own actions.

b) It appears that there is no government oversight of well drilling operations to date to protect the environment and potable water resources that are critical to the whole NT. This must be introduced.

c) Gas producers are to become the environmental monitors of their own performance. Third party monitoring is required for existing water wells and future monitoring wells and all surface operations to provide the vitally important information to inform any changes to HFS operations that are needed to protect personnel, agricultural productivity, other businesses and the environment. This should be funded by government and paid for by gas producers. Having the fox in charge of the hen house is never a satisfactory arrangement.

d) The review and changes (in the government pipeline) to the relationship between the Petroleum/Mining and Water Acts needs to be completed. Gas producers require water licencing and approval exactly the same as agricultural and industry does in relation to use of water resources. The potable water reserves in the NT are critical to life and are limited; therefore regulation of HFS water use is an absolute necessity to preserve this critical future asset and the sustainable agricultural production into the future. Aquifer water use for HFS will potentially be equal to, or more than all current aquifer use in the NT. Ground water in the NT provides 85% of the water used in agriculture and to risk this resource would be criminal. The Water Act should apply to gas producers aiding protection of the critical ground water resources.

e) The actual aquifers that are used for HFS needs to be controlled , licenced and regulated by DENR. The use of the Tindall/Gum Ridge aquifers, and the Bukalara sandstone aquifer should be avoided wherever possible.

f) There are massive legacy issues relating to abandoned gas wells at 800 metre centres and the land surface changes that will take place should wholesale HFS proceed. If we assume that there are to be 20,000 gas wells at 2500 metre vertical depth in the Georgina Basin; the total cost just to plug all these abandoned wells is at today's cost **A$1.5 billion dollars[9].** An isolated environmental fund must be created from funds provided by well owners and gas producers from day one to cover all this environmental restoration. Casing failures will occur in future due to anaerobic and acidic species attack; casings are not stable long term underground.

g) There will be gas leaks of methane and hydrogen sulphide from well casings and plant and equipment, this cannot be avoided only mitigated, therefore gas producers must supply the relevant personnel protective and monitoring devices for all personnel working, including those involved in primary production where underground water resources are used, in the vicinity of gas and water wells in the Beetaloo basin. HFS automatically weakens/cracks the cement outside production casings, as well as off target induced fractures in geological strata, hence gas leaks cannot be completely prevented. Contamination of water aquifers by gas will occur. This OH&S issue needs to be included in any production licence.

h) The number of casings used by gas producers, to isolate and maximise the protection of the potable water aquifers, Tindall and Bukalara aquifers,

appears to be insufficient in exploration wells. Mr Dunbar is aware of massive numerous cavities in and near both the above aquifers, and as a result drilling through any cavity reduces the aquifer protection because the outer casing and cement becomes ineffective. The NT government needs to specify the minimum number of casings and cementing through these aquifers.

i) Below ground strata containing very high levels of hydrogen sulphide have been observed by Mr Rod Dunbar. The NT government needs to specify the higher grade casing materials required to prevent casing stress fractures caused by hydrogen sulphide containing formations.

j) Seismic monitoring must be initiated in the Beetaloo basin to inform the potential for serious earthquakes in view that there will be blanket fracturing of the rock over thousands of square kilometres. In addition the potential for reinjecting waste water as a disposal method and its impact on seismic activity needs to be controlled.

k) The NT government needs to specify/regulate the plugging and abandonment standards e.g., cement plugging should be carried out to a specific depth and methodology to ensure that the potable water aquifers are isolated from the non potable water aquifers and the gas/oil formations to provide protection when the casing eventually rot in future.

l) Government supervision, regulation and control of the treatment storage and disposal of fracking return waste water and gas line condensate is required. The geological formations in the area are known to have radioactive species and/or high fluoride content. This along with the fracking chemicals present an environmental risk when wholesale fracking takes place using up to 17GL of water per annum.

m) The prevention of the loss of the threatened species in the Beetaloo Basin. Any waste water storage facilities or ponding will be a direct threat to the threatened species Gouldian Finch and Australian Painted Snipe.

1. Introduction

We were requested to review the impact of the fracking potentially possible on the Nutwood Downs for the Dunbar family. The aim of our review was to assess the risks associated with Origin HFS gas wells in particular in relation to Nutwood Downs. Origin is the operator in relation to Falcon Oil and Gas Australia exploration permits in the Beetaloo basin

Much of the leasehold land in the Northern Territory is only agriculturally productive as a result of the availability of potable quality water during the dry season. In particular some of the shallow aquifers contain high quality potable water suitable for irrigation, but more important currently providing high quality stock water for cattle grazing operations. Any threat to the quality and quantity of this high quality water supply must be considered as a direct threat to the sustainability, profitability and valuation of agricultural and tourism operations in the Northern Territory where water is critical to all agricultural enterprises during dry seasons and failed monsoon seasons.

It appears from recent press releases[4] that the NT Government has already decided to proceed with fracking irrespective of the current inquiry. This conclusion is also supported by the May 2017 aquisition of the Sasol Petroleum Australia Limited's 35% stake in the Beetaloo gas reserves by Origin[5] and the approval of the next stage on the Northern Gas Pipeline[7].

2. Fracking Economics

The long term World Bank LNG price for Japan concludes prices in the short term 2018 to 2020 are near US$7.50/mmbtu[1]. Japanese contracts are the major destination of LNG from Australia and in particular Origin, and the driver of a domestic gas shortage and elevated prices for natural gas in the eastern Australian market.

The decision by Japan to close nuclear reactors around 2010, after Fukisima, and replace this energy source with LNG has been a major driver of elevated Japanese LNG prices in the short term. These contracts are related to crude oil prices/indexes which have dropped 50% in the years since Origin signed its huge contact with Kansai Electric in Japan. If we assume that the Origin/Kansai Electric contract was signed at the historical LNG price in Japan (no actual prices could be sourced) it would be of the order of US$16/mmbtu and applying the Japanese crude index, that has fallen substantially, the current Origin LNG price in Japan would be of the order US$7.50/mmbtu.

With reference to APPEA 2014 Report into Unconventional Gas in the NT[2] the breakeven cost for LNG sales via Darwin to Japan is A$12.78 per GJ (US$9.98/mmbtu).
US production of LNG is also ramping up and their liquefaction costs are less than 50%[6] (US /mmbtu) of those in the APPEA report[2] for the Beetaloo Basin, that is A$4.00/mmbtu.
"Liquefaction is one of the most expensive costs throughout the LNG value chain, and it can range from $3.00 per MMBtu (millions of British thermal units) for brownfield projects in the United States to as high as US$10.00 per MMBtu in Australia for greenfield projects, so that investors can generate decent returns, based on a study done by the Canadian Energy Research Institute."
See Figure 1

It appears therefore that Australian gas producers have committed to supply contracts in Asia that they are having difficulty supplying, and that the current prices achieved for LNG exports are below cost. This requirement to supply overseas contracts then generates a local gas shortage; while at the same time the elevated local gas price, A$8.29 per GJ[2], would provide a better market at higher profit margins, because the gas does not have to be liquefied. Refer page 19 APPEA report[2] *"Domestic gas prices will no longer be driven primarily by local factors. The higher opportunity cost of gas, made possible by the development of LNG export facilities, are expected to drive East Coast prices towards export price parity"*

Japan, China and India are installing hundreds of high efficiency coal fired power stations. This alone will induce an LNG glut reducing profitability on LNG production further. The highest price for thermal coal in Australia has been less than A$6.00/mmBTU, much lower than natural gas prices. When Australia finally comes to its senses, in relation to the global climate control

sham, we will re-install coal fired power stations to utilize our major most cost effective fossil fuel energy resource coal.

This lack of profit for export LNG then impacts the proper compensation of landowners and seriously impacts the ability of the gas producer to do the necessary plugging and environmental clean ups etc.in future. Hence there is a dire need to quarantine potential plugging and field abandonment funds now.

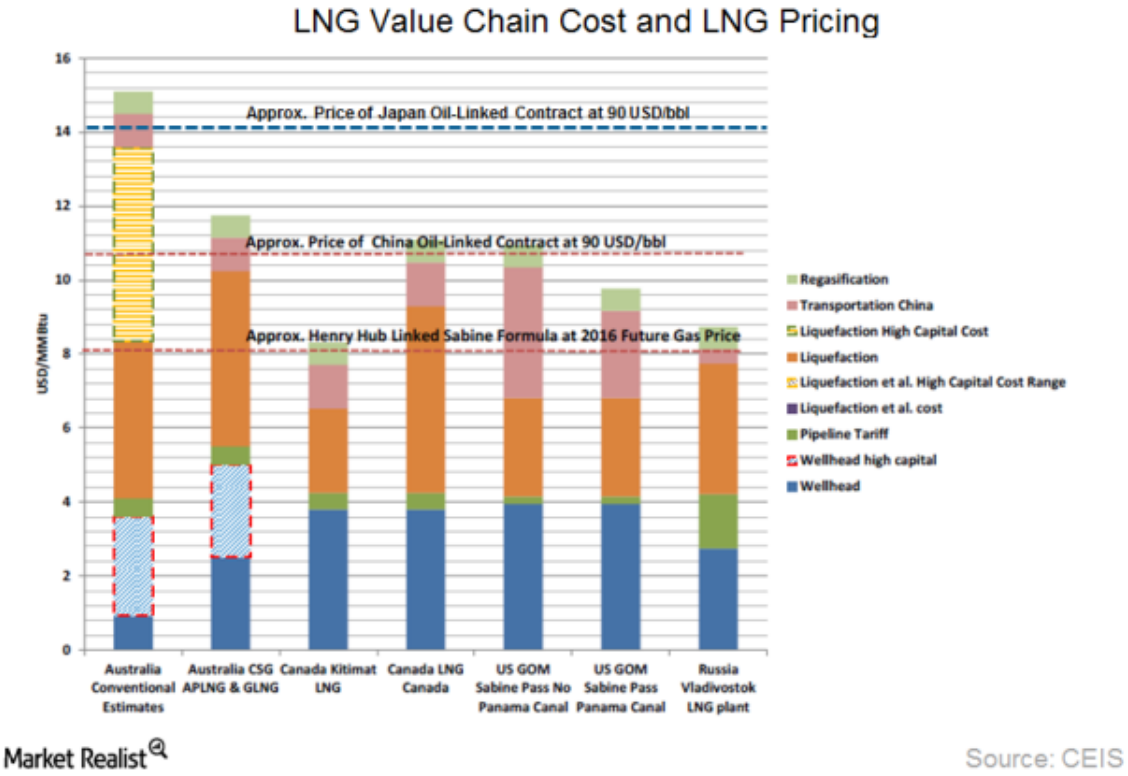

Figure 1

3. Employment

It is doubtful that there will be a significant long term impact on employment and living standards in the NT as a result of fracking. While some employment is generated by construction phases; these are specialised workers in short supply, moving from project to project, not locals. Once the construction phase is over, the production and liquefaction processes are highly automated requiring little local labour input due to fly in fly out manning. The RBA report[3] confirms this "*The ramp-up in LNG production will boost Australian output and incomes over the next few years; however, the effect on Australia's living standards will be lessened to some extent by the high level of foreign ownership and the relatively low labour intensity of LNG production."*

The reported and published increases in employment figures[2] of 4200 might be initial for construction, but in the longer term extremely questionable. These figures are always inflated to get public support.

4. Water

"The current Water Act by virtue of Section 7 Exempts mining and petroleum activities from licence and permit requirements" page 6 DENR Report[8]. As a result these water usages and any associated environmental issues are invisible to both the public and the NT Government.
This needs to change before gas production commences so that the aquifers utilised for fracking are known and controlled to preserve potable water supplies for agricultural, potable use and tourism requirements, while maintaining the environmental flows required for the environment.
The NT Government must enable and fund monitoring and data collection from drilling locations

in their role that should be managing and controlling operations within strict guidelines rather than abdicating its responsibility to the general NT population and landowners, by permitting gas producers to go ahead without adequate oversight.

Tindall Limestone Aquifer

While fracking operations a reportedly supposed to use saline groundwater where available, not potable ground water, one would assume that there will be little impact on potable water aquifers from level depletion. However it our belief that it will be the potable water from the Tindall aquifer supplying fracking water and not the Moroak sandstone layer where highly saline water exists that is unsuitable for any other use. We believe that the exploration wells drilled to date used Tindall Aquifer water.

The Northern Territory Government Ground Water Resource Assessment – North Mataranka to Daly Waters[18] indicates that 66 GL/year is available for allocation or 20% of the estimated 330GL/yr of ground water recharge. 26 GL/y is already allocated leaving 40GL/y for further allocation. There is complete confusion/secrecy around the actual water requirements of fracking.

With reference to the pages 9, 10 and 11[18], Nutwood Downs has three government monitoring bores RN38812 to RN38814 located on the property. The Tindall Limestone layer here thins abruptly and thins to 16m in at RN38814, and is considered to be the furthest extent of the Tindall limestone aquifer to the north east. Airlift yields 2.8 and 2 litres per second were obtained for RNN38812 and RN38813 respectively. These yields are about 10% of potential yields further north and west.

At this time we believe that none of the Tindall Limestone aquifers show any contaminants that could be related to gas and oil formations lower down. The quality of all water bores needs to be established now by independent baseline sample collection and analysis funded by the NT Government to provide actual data on the impact of fracking on these critical aquifers.

Nutwood Downs has 8 water bores in the Tindall aquifer close to the extremity of the aquifer. There is a risk that using the large volume of water required to say produce from 400 HFS gas wells on Nutwood Downs, and HFS gas wells on other adjoining properties in the basin from the Tindall Limestone aquifer, should it be used for fracking water supply, will seriously impact these bores to the point they will be useless, or have substantially reduced water volumes or standing water levels available, potentially making the agricultural grazing business non viable. Any reduction in the standing water levels on Nutwood Downs can be expected to reduce and/or stop potable water supply from the bores because their location is close to the extremity of Tindal aquifer.

In addition high HFS use of limestone aquifer water in the Georgina Basin, which is the much deeper formation, may modify the boundary location of the Daly and Georgina Basins, which in turn impacts the aquifer extremity bores at Nutwood Downs in the Daly Basin. Even if HFS production does not occur on Nutwood Downs there could be impacts from water depletion from both the Daly and Georgina water basins. The rectification costs associated with the declining standing water levels in existing bores as a result of high HFS ground water use needs to be addressed in view that the properties affected may be remote from the HFS operations.

Government legislation and regulation must address the issue of providing reliable good quality unpolluted ground water for leasehold land agriculture if it proceeds to allow extensive production licencing of HFS gas wells in the Daly and Georgina basins. If this is not addressed financial losses are highly probably for the government, businesses and agricultural leaseholders, all relying on the availability of potable water in the Beetaloo Basin.

Bukalara Sandstone

Nutwood Downs operate approximately 13 bores in the Bukalara sandstone formation. The Tindall limestone aquifer at these locations does not provide sufficient water to be of use. Mr Rod Dunbar in his experience as a bore driller, has experienced sandstone formations containing very high hydrogen sulphide concentrations in our near the Bukalara sandstone formation.

As a result penetration of this sandstone with convention steel casing could result in casing failures in a few years with resultant blow outs and environmental damage. Gas

producers need to consider extra casing or higher grade alloys for vertical wells to prevent environmental damage from stress cracked casing in short time frames. The NT government needs to regulate and specify casing materials suitable for high sulphide environments.

Fracking Waste Water

The estimated water requirement for HFS gas wells in the Georgina basin published by Frogtech[A1] is 17GL per year, 5% of the Tindall aquifer recharge rate, or 65% of the current water allocation. Therefore there will be substantial quantities, up to 17GL per year based on the Frogtech information[A1], of highly saline, chemically contaminated waste water returned from fracked wells. The method of disposal of this quantity of water is unclear and presents a serious environmental issue e.g. With reference to the DENR report[8]," *An environmental challenge in accessing shale and tight sand gas is the relatively poor quality flowback water from hydraulic fracturing stimulation and produced water, where the produced water from the target formations is typically of high salinity incorporating naturally occurring radioactive materials, dispersed oil and soluble organic compounds."* This section of the DENR report misses the fact that there are numerous chemical additives to the fracking water that are also undesirable in potable water, aquifers and rivers.

The impact of ponds containing this fracking wastewater on the threatened bird like the Gouldian Finch and other species on the Beetaloo Basin needs to be considered.

5. Compensation and/or Royalty payments

With reference to Appendix A2, it is an insulting financial proposition to consider granting gas producers access to Nutwood Downs for HFS gas production. Ignoring the one off payments the Origin offer is A$3,500 per annum adjusted for CPI for access to drill somewhere between 1 and 400 gas wells, a similar number of fracking water wells, install roads and plant etc.

In comparison if the land has Aboriginal Title the following applies[2] [1]*"Around half of the NT is covered by the Aboriginal Lands Right Act (ALRA). Successful development of some shale and tight gas resources would therefore be expected to take place on ALRA land. Under the Act, the Commonwealth makes matching payments to the Land Councils equal to the value of royalties paid by resource companies to the NT Government. The Land Councils distribute these funds to communities.*

The remaining land in the NT is largely covered by Native Title. On Native Title and ALRA land, the Land Councils receive royalties and fees from the operators that are additional to ALRA payments and royalties to the Government. Payments to Land Councils and Aboriginal communities through the ALRA and Native Title Act can at least match (and often exceed) the royalties paid to the NT Government"

So let us assume there were 100 wells drilled on Nutwood Downs, where native title has never been established, each producing 1 million standard cubic feet per day for 20 years:-

Total Payment to the Dunbar family (no CPI) - A$92,500 / 20years

If the Dunbar's were Aboriginal on Aboriginal Title-Total Payment - >A$200,000,000 / 20 years Wellhead price A$3/mmBTU, equivalent 10% royalty.

There is no doubt that the leaseholder will experience a massive financial negative impact, on his/her business that he must continue to operate to survive financially, while Aboriginal Title holders have no need to pursue any kind of business/income activity to survive. We can't see

how racial harmony can ever survive under this massive combined discrimination by Origin, the Territory and the Commonwealth.

6. Origin Risk Analyses

There are massive shortcomings in relation to the Ammungee NW-1H Origin Risk Assessment attached[A3] or their report CDN/ID NT-2050-35-PH-0018 2016 Hydraulic Stimulation and Well Testing EP Summary (Amungee NW-1H). This risk assessment only really considers environmental impacts primarily and completely ignores the financial risk their operations pose to the agricultural leaseholder. The relevant section of the risk assessment are predominantly blank if relation to financial impacts. This same lack of consideration to the financial impact of HFS to leaseholders into the future appears permeate much of the origin documentation, including their atrocious compensation offer[A2] to Lexcray Pty Ltd.

Should HFS commence on a production scale on lease hold land there are a multitude of financial impacts that need to be considered, documented and compensated for.

The financial risks that need to be covered by Origin for the leaseholder includes:-

a) The subsequent depletion of ground water levels for existing bores and a methodology to restore, at no cost, a suitable water resource for leaseholders should it be depleted, or in the event of no suitable replacement being available.

b) The contamination of existing bores and a plan to restore or compensate for the contamination.

c) Compensation rent and royalties for the lease holder from the gas well and gas production, to offset the financial losses resulting from the placement of numerous gas wells at regular intervals, the gas pipelines, production facilities and roads; that interfere with the normal operation of the agricultural lease.

d) The funding of well plugging and surface remediation at the end of the productive life of the operations.

7. Drilling and Casing

Drilling and casing in the Beetaloo Basin and Nutwood Downs requires that the cavernous[18] Tindal Limestone Aquifer, containing high quality potable water, is penetrated. Origins own report[A5] states on page 42 *"**Gum Ridge Formation** – The Gum Ridge formation is described as a cavernous limestone. It is the regional aquifer for local domestic and commercial use and it is therefore important to isolate from cross flow contamination. Given its description as a cavernous limestone, it is highly likely that total losses would be taken during drilling"* We assume that encountering a cavernous void would not mean that the hole would be abandoned and hence any attempted casing/cementing through the caverns or voids automatically negates the well casing protection afforded by the first casing. The NT Government needs to ensure that wells are abandoned where caverns are encountered, the risk of unsatisfactory completions is high, if attempts are made to case through caverns.

Origin employed the consultants CloudGMS Pty Ltd[A4] to prepare a ground water impact assessmsnt for the Beetaloo Basin which primarily covers exploration drilling. From their report[A5];

"6) EXPLORATION DRILLING ENABLES CROSS FORMATIONAL FLOW BETWEEN SHALLOW AQUIFERS IN CONTRAVENTION OF WATER ACT REGULATIONS.
Assessed Risk Level: HIGH
Consequence: Serious
Likelihood: Likely
There is potential that incomplete casing/cementing of shallow utilised aquifers will allow cross formational flow. This will contravene Water Act (NT) regulations, which require effective isolation of multiple aquifers to prevent cross formational flow. Assuming there is a contrast in water quality between the aquifers and a driving pressure gradient, potential also exists for the deterioration in

groundwater quality, which in turn could impact existing groundwater users and/or environmental dependencies."

A subsequent Origin report downgrades this Assessed Risk Level to MEDIUM

CloudGMS indicated that their concerns had been addressed by Origin but the subsequent Amungee NW-1H well does not indicate any change in relation to the protection the Tindal Aquifer where a cavern was encountered.

In view that the Water Act (NT) does not apply to mining and petroleum operations should be a major cause for concern when risk levels of Medium and High are reported in gas producer literature with serious consequences. The Water Act should apply to maximise protection of the Tindall aquifer.

Irrespective, the penetration of the critical Tindall Limestone Aquifer presents both a short term and long-term risk as assessed by CloudGMS Pty Ltd, because this aquifer is riddled with cavities and caves which make vertical drilling difficult and cementing the largest casing impossible or flawed wherever a cavity exits.

We recommend that in all cases should HFS gas well drilling and casing be carried out that the initial conductor (usually 16 inch casing) be extended to within the top of the Atrium Volcanic (basalt) layer. This would provide extra protection to the internal 10.75 inch casing and cement should small limestone cavities prevent the adequate protection of the conductor and provide an extended well life before the well is plugged.

Irrespective of the mitigation in place, current leakage rates for gas wells is at least 2%[15], hence the necessary occupational health and safety procedures need to be in place to prevent injuries, loss of life and on or near properties where HFS wells are located. It is not possible to drill thousands of gas wells without some well integrity failures. This comment particularly applies to pastoralists and their employees where they frequent their own water bores that have been gas contaminated, with potentially poisonous hydrogen sulphide and/or flammable methane. Gas production companies must cover the cost of this OH&S issue.

The NT government must put in place a third party mechanism for checking well barriers and integrities of all shale gas wells that have not been plugged and abandoned.

Mr Rod Dunbar has encountered hydrogen sulphide containing formations in the vicinity of the Bukalara sandstone layers. Drilling companies will need to bear this in mind in view that stress corrosion cracking can occur with catastrophic failure of steel casing strings[20.] The Northern Territory (NT) government needs to consider the potential ramifications of this and the requirement to specify alloys, to prevent possible casing catastrophic failure and environmental pollution.

The NT government also needs to consider the number of casing required to provide adequate protection of the Bukalara sandstone aquifer and specify these.

8. Environmental

The primary environmental risk to all businesses in the area and agriculture is the loss of potable water supplies from the two aquifers; firstly the Tindall Limestone and secondly the Bukalara sandstone formations. The two major risk factors are contamination or reduction in the standing water levels by HFS. The change in standing water levels and any contamination of the potable water resources will affect businesses outside of the drilling locations. Legislation absolves the drilling and exploration companies of compliance to the Water Resources Act. This alone confirms that both the NT Government and the exploration and production companies are aware that damage or decline to the existing potable water resources is highly probable. The exact water consumption is not available and in fact is dependent on how many fracks are required to make the gas formation suitably porous for optimum gas production. This water consumption should be on the same basis as existing irrigation users, not outside existing legislation and regulation, and without payment for the resource.

The secondary risk is the damage and modification to the surface natural environment and its direct impact on both the property owner/leaseholder, and threatened species like the

Gouldian Finch. These threatened species issues come under the Commonwealth EBPC Act. Any production scale HFS automatically provides polluted water sources that will affect the remnant critically endangered Gouldian Finch[16] and Australian Painted Snipe[17] populations known to frequent Nutwood Downs and the Beetaloo Basin. Finches and Snipe frequent pooled water and the numerous low point drains and ponds containing contaminated and polluted water will be an alternative to existing potable stock water troughs, dams and natural ponds.

The surface environment will also be altered by gas the gas leaks already documented.

9. Well Abandonment

There are massive financial, and therefore environmental impacts, associated with drilling hundreds of HFS unconventional gas wells, and in particular these financial risks could mean that 28,000 gas wells and associated installations are abandoned in the Georgina Basin[A1] and there are no or insufficient funds available for plugging of the casings that will eventually fail due to corrosion and/or mechanical failure. The DENR statement on page 8 of their submission[8] highlights this issue *''The integrity of the well must be guaranteed for the long term which raises the issue about who bears the responsibility for a deteriorating well which has been abandoned. Consideration of proportional security measures through provision of bonds or guarantees would address any potential legacy issues."* This type of financial risk has already been encountered in the Alberta Canada[15,19] for conventional wells *"In Alberta, the Provincial Government has established an 'Orphan Well' fund based on a well levy which can be used to remediate any wells where the operator has ceased to exist or cannot be traced."*

In the case of shale gas wells however the plugging financial and environmental risk for HFS gas wells is **exponentially** higher because of their number in relation to the historical number of conventional wells per comparable area. A calculation, using the average cost of A$30 per metre for plugging, based on the paper The Rising Cost of Clean Up After Oil and Gas[9], for 28,000 (2500 metre) HFS gas wells in the Georgina Basin would require a fund of $2.1 billion at today's costs. In the case of Nutwood Downs where potentially 400 wells could be drilled this amounts to A$30 million to plug abandoned wells in the long term. No government that cares about the financial future of Australia would commit to HFS gas wells without financial security for plugging these wells which will fail in the longer term risking the one resource, potable water, that is required by the remaining sustainable business's and agriculture. With the negative profits margins for export LNG, where are the funds for environmental cleanup and plugging of abandoned wells coming from?

The risks we see as possible are tabulated below, however this list may be incomplete:-

a) Financial failure, bankruptcy or other financial limitation of the well owner e.g., in the case of Nutwood Downs this would be Falcon Oil and Gas Australia Ltd (located in Dublin Ireland).
b) Financial failure or bankruptcy of the operator, in this case Origin Energy.
c) A reduction or collapse of the oil/gas/energy prices on the world market making production uneconomic, however the thousands of wells are left idle and unplugged. We believe LNG prices are already be at uneconomic levels for production from the Northern Territory.

In view of these actual risks, a fund independent of government and industry coffers must be established to enable the plugging of all wells and the rehabilitation of ancillary sites involved in the broad acre HFS program.

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Appendices

A1. Frogtech Table
A2. Schedule 1 Origin Pastoral Land Access and Compensation Agreement – Lexcray Pty Ltd.
A3. AECOM – Origin EP Risk Assessment – Beetaloo Joint Venture
A4. Consultants – Authors of Amungee EIS
A5. https://minerals.nt.gov.au/__data/assets/pdf_file/0007/369808/Amungee-nw-1h-hydraulic-fracture-stimilation-and-well-testing.pdf

Basin	Basin area (km2)	Number of shale gas wells	Water needed for fracking (GL)	Fracking water per year (GL)	Groundwater sustainable yield (GL/yr)	Groundwater abstraction (GL/yr)	Water footprint compared to gas footprint
Amadeus	162,294	12,679	190.2	7.6	142	14	26
Arckaringa	87,331	6,823	102.3	4.1	12	11	167
Bowen	161,559	12,622	189.3	7.6	224	101	17
Canning	534,046	41,722	625.8	25.0	834	22	15
Clarence-Morton	45,861	3,583	53.7	2.1	705	168	1.5
Cooper	121,382	9,483	142.2	5.7	20	29	139
Galilee	337,973	26,404	396.1	15.8	106	99	73
Georgina	362,638	28,331	425.0	17.0	241	64	34
McArthur	198,480	15,506	232.6	9.3	749	9	6
Officer	333,657	26,067	391.0	15.6	249	<1	31
Otway (onshore)	44,105	3,446	51.7	2.1	1,998	238	0 5
Perth	186,678	14,584	218.8	8.8	1,609	677	3
Sydney	60,630	4,737	71.1	2.8	896	79	2
Wiso	138,586	10,827	162.4	6.5	106	4	30

Table 2: Shale gas basins in Australia showing the potential number of wells (assuming well space of 800 metres and fairways making up 5% of the basin). The estimated volume of water needed to frack these wells assumes 15 ML/well. The volume of fracking water per year assumes a 25 year life span of the field.

Groundwater sustainable yield and groundwater abstraction values from NLWRA (2001) and AWR2005 (http://www.water.gov.au/). Shale gas basin boundaries were used to clip all groundwater management units (GMUs) within the shale gas basin and a *pro rata* estimate of sustainable yield made based on NLWRA 2001. Water footprint is the factor by which the area of land needed to sustainably withdraw 15 ML of water for fracking exceeds the area of land (640,000 m^2) covered by each gas well.

Schedule 1
Compensation

1. The Operator will pay the Pastoralist Compensation as follows:

   (a) an upfront payment of $12,500 within 30 Business Days of the Agreement Date;

   (b) $3,500 per annum for the second year and each subsequent year of this Agreement, in advance on or before each anniversary of the Agreement Date for the remainder of the term of this Agreement (prorated for any partial years of the Term);

   (c) $5,000 within 30 Business Days of the Agreement Date for personal inconvenience incurred in negotiating this Agreement (on phone or in person), driving the Operator's Personnel around the Pastoral Property, considering the Operator's work programs and variations to them (or this Agreement), visiting with the Operator, the Operator's sites and considering and providing consent in accordance with this Agreement; and

   (d) up to $5,000 for legal and accounting costs reasonably and necessarily incurred by the Pastoralist in respect of the negotiation of this Agreement. Payment will be made within 30 Business Days of receipt of an Itemised Bill invoiced to the Pastoralist or the Agreement Date, whichever is the later.

2. All annual payments that fall due on or after the second anniversary of the Agreement Date must be varied by the CPI calculated in accordance with the following formula:

$Pn = Po \times (1 + \frac{[CPIn - CPIo]}{CPIo})$ Where:	
Pn =	the compensation for the year for which the compensation is being determined
Po =	the previous annual compensation payment (or appropriate apportionment of the last payment prorated as described above in paragraph 1(b) above).
CPIn =	the CPI most recently published by the Australian Bureau of Statistics
CPIo =	the CPI for the same quarter of the previous year as published by the Australian Bureau of Statistics

Risk Ref	Activity	Aspect	Location	Impact	Impact Description	Pre Mitigation Risk Assessment						Mitigation Measure (Note preliminary mitigation, full mitigation presented in Section 5.0 Potential Impacts and Management)	Post Mitigation Risk Assessment																		Risk Band
						Impact to Origin or Contracting Personnel	Natural Environment	Community Damage / impact / social /cultural	Financial Impact (e.g. due to loss of revenue, business interruptions, commodity, trading, asset	Damage to reputation, services	Breach of Law or Criminal Prosecution or civil		Impact to Origin or Contracting Personnel			Natural Environment			Community Damage / impact / social /cultural heritage			Financial Impact (e.g. due to loss of revenue, business interruptions, commodity, trading, asset			Damage to reputation, services interruption, customer interruption			Breach of Law or Criminal Prosecution or civil action (e.g. OHS, environment, industrial			
						Consequence	Consequence	Consequence	Consequence	Consequence	Consequence		Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	Consequence	Likelihood	Risk Level	
18	Camp Operations	Waste	All sites	Encouragement of pest species to waste sites.	Incorrectly managing waste on site could potentially attract pest species.		2				1	- Segregate and safely store and label chemical packaging, lube oils, batteries, tyres, maintenance and other industrial wastes for proper disposal to recycling and approved landfill facilities. • All waste material introduced to site will be removed from the lease area and disposed of, e.g. discarded drilling equipment, oil drums, machinery, engine debris, food and drink packaging etc.. • All sample bags, waste materials and contaminants must be removed from site and disposed of in an appropriate manner, following the completion of the drilling program.. • Drill cuttings that are acidic, radioactive or of a substantially different colour to the surface soil should be backfilled in the drill hole, sump or other excavation. All other cuttings should be dispersed around the site or raked over.	1	1	Low	1	1	Low	1	1	Low	1	1	Low	1	1	Low	1	1	Low	Low
19	All activities	Air Quality and Emissions	All sites	Potential for an increase in dust during site preparation (clearing of access tracks, drill sites and camp areas) and resulting from vehicular traffic	Dust - The road network within the permit area is almost entirely unsealed and dust is generated as a result of vehicle movements upon these roads during the dry season. Dust generation also occurs on other areas of the permits where vehicles are used off		1				1	- Ensure site environmental inductions for all site personnel and contractors include air quality management and protective measures to control or report air emissions. - all vehicles and equipment used on site will be well maintained with mufflers fitted. - Monitor road conditions to Ensure deterioration with possible increase in Dust creation, does not occur and undertake road rehabilitation if required. - use water truck where applicable to manage Dust emissions from vehicle movement or drilling operations on the site.				1	3	Low										1	1	Low	Low
20	All activities	Air Quality and Emissions	All sites	Potential for an increase in exhaust emissions from contractors' vehicles and generators resulting in localised effect on air quality and global contribution to greenhouse gases.	Vehicle Emissions - Vehicle exhaust emissions are a current occurrence in the region as a whole, from users of the national highways and pastoral machinery. Portable diesel or petrol fuel generators may be used during the exploration phase and a larger		1				1					1	1	Low										1	1	Low	Low
21	All activities	Air Quality and Emissions	All sites	Potential for dust generated to impact on health and functioning of the surrounding vegetation.	Excessive dust deposited onto plant foliage can reduce the photosynthetic performance (photosynthesis, stomata conductance, transpiration etc.), thus reducing overall health and plant growth (Hirano 1995) although the type and severity of impacts is largely unknown. On the drill site, the		1				1					1	3	Low										1	1	Low	Low
22	All activities	Air Quality and Emissions	All sites	Potential for an increase in volatile hydrocarbons present in air surrounding drill sites, as petroleum compounds are moved to the surface	Hydrocarbon Emissions - There may be a periodic requirement to burn waste hydrocarbons in the flare pit, during the drilling process (e.g. during the drill stem test). The management of this has been discussed in the EP, but the process itself		1				1					1	1	Low										1	1	Low	Low
44	Well stimulation	Groundwater	Frac Stimulated wells	A surface spill of stimulation fluids /flow back water/diesel leads to the contamination of groundwater resources.	Contamination of shallow aquifers by flowback/formation water impacts existing/ potential groundwater users (landholder) and environmental dependencies. Relatively shallow groundwater occurrence. Unsaturated zone sediments are permeable and provide pathway to watertable aquifer. Likelihood of groundwater contamination resulting from surface spillage is low when taking in consideration watertable depth, spill volumes and existing controls. Community impact is related to potential		2	2				Tank integrity is tested during commissioning and prior to any flowback water being pumped in. Regular tank inspections and integrity checks. Planned groundwater monitoring activities. Ability to transfer between tanks. Spill kits and drip trays used to manage small leaks. Excess storage capacity available. Pressure tested surface lines to ensure piping connection integrity				2	2	Low	2	2	Low												Low
45	Well stimulation	Groundwater	Frac Stimulated wells	Leakage of frac flowback from storage vessels leads to the contamination of groundwater resources.	Contamination of shallow aquifers by flowback/formation water impacts existing groundwater users and environment.		2					Tank integrity is tested during commissioning and prior to any flowback water being pumped in. Regular tank inspections and integrity checks. Planned groundwater monitoring activities. Ability to transfer between ponds. Spill kits to manage small leaks. Excess storage capacity available.				2	1	Low												Low
46	Well stimulation	Groundwater	Frac Stimulated wells	Groundwater extraction required to supply water for the project results in drawdown of water levels which impacts existing groundwater users and/or the environment.	Pastoral groundwater bores suffer impaired capacity (ie. Reduced bore yields). Reduction in environmental flows in connected springs/rivers.		2					CloudGMS risk assessment modelling predicts nil impacts.				1	1	Low												Low
47	Well stimulation	Groundwater	Frac Stimulated wells	Cross flow of groundwater from a utilised aquifer to another formation causes declining groundwater levels.	Pastoral groundwater bores suffer impaired capacity (ie. Reduced bore yields). Reduction in environmental flows in connected springs/rivers.		2					OE DMS and adherence to industry best practice. Well control critical equipment and systems on rig fit for purpose, certified, maintained in good work order and tested as required. Appropriate well control training/certification for rig personnel. Well engineering design compliant with best practice and Origin standards (Casing Design and Barrier Philosophy). Pressure test verifying integrity of the string.				2	2	Low												Low
48	Well stimulation	Groundwater	Frac Stimulated wells	Stimulation activity enables cross formational flow between shallow aquifers in contravention of Water Act (NT) Regulations.	Deterioration in water quality in utilised aquifer impacts existing groundwater users and affects environmental dependencies (springs, ecosystems).		2	3				Programme Design. Stimulation design.				2	1	Low	3	1	Low									Low
49	Well stimulation	Groundwater	Frac Stimulated wells	Hydraulic fracturing induces seismicity which increases connectivity between formations and enhances the potential for cross flow of water /hydrocarbons/gas.	Change in flowpaths and aquifer interconnection leads to flow of groundwater between formations and results in contamination of utilised aquifer and impacts on existing pastoral use and environmental		3					Significant distance between target reservoir formation and aquifers Presence of natural frac barriers and high perm zones to contain fracture height growth Fracture stimulation design to contain height growth				2	1	Low												Low

Risk Ref	Activity	Aspect	Location	Impact	Impact Description	Pre Mitigation Risk Assessment						Mitigation Measure (Note preliminary mitigation, full mitigation presented in Section 5.0 Potential Impacts and Management)	Post Mitigation Risk Assessment																		Risk Band
						Impact to Origin or Contracting Personnel	Natural Environment	Community Damage / impact / social /cultural heritage	Financial Impact (e.g. due to loss of revenue, business interruptions, commodity, trading, asset	Damage to reputation, services	Breach of Law or Criminal Prosecution or civil		Impact to Origin or Contracting Personnel			Natural Environment			Community Damage / impact / social /cultural heritage			Financial Impact (e.g. due to loss of revenue, business interruptions, commodity, trading, asset			Damage to reputation, services interruption, customer interruption			Breach of Law or Criminal Prosecution or civil action (e.g. OHS, environment, industrial			
						Consequence	Consequence	Consequence	Consequence	Consequence	Consequence		Consequence	Likelihood	Risk Leve	Consequence	Likelihood	Risk Leve	Consequence	Likelihood	Risk Leve	Consequence	Likelihood	Risk Leve	Consequence	Likelihood	Risk Leve	Consequence	Likelihood	Risk Leve	
50	Well stimulation	Natural Environment - Seismic	Frac Stimulated wells tes	Hydraulic fracturing induces local seismicity and reactivates a fault.	Noticeable seismic tremor at surface. Negative Impact to perceptions regarding hydraulic fracturing.		2	1				30-40m on either side of known fault has been blanked.				2	1	Low	1	1	Low										**Low**
51	Well stimulation	Water	Frac Stimulated wells tes	Delayed decision regarding appropriate disposal mechanism results in inadequate water disposal.	Local contamination resulting in potential environmental impact.		3					Daily pH sampling of water. Water Management Plan.				3	2	Medium													**Medium**
52	Well stimulation	Natural Environment - Fauna	Frac Stimulated wells tes	Water storage on site negatively impacts fauna.	Fauna ingress into water storage resulting in potential fauna mortality.		3					Tanks are of sufficient height mitigating ground dwelling fauna entering tank.				3	1	Low													**Low**
53	Well stimulation	Natural Environment - Contamination	Frac Stimulated wells tes	Radioactive elements (NORMs) in the formation are carried back by the water or in fines production.	Personnel exposure. Potential damage to ecosystem in the event of inadequate disposal.	3	3					Limited exposure time for personnel. NORMs testing will be undertaken throughout the programme. Adequate disposal of NORMs will be undertaken.	3	1	Low	3	2	Medium													**Medium**
54	Well stimulation	Groundwater	Frac Stimulated wells tes	Loss of well integrity during frac programme.	Potential contamination of aquifer in the event of loss of integrity.		2					OE DMS and adherence to industry best practice. Well control critical equipment and systems on rig fit for purpose, certified, maintained in good work order and tested as required. Appropriate well control training/certification for rig personnel. Well engineering design compliant with best practice and Origin				2	2	Low													**Low**
56	Post Drilling & completion (not activity specific)	Groundwater	All stes	Cross flow of groundwater between shallow aquifers results in deterioration of water quality in utilised aquifer.	Deterioration in water quality in utilised aquifer may impact existing groundwater users and environmental interdependencies.		3					completion design - cementing between aquifers verification of barriers - cement bond log, pressure tests (?) with failed/partial barrier flow path still restricted *** limited pressure differential (limited driver for flow)				1	2	Low													**Low**

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