Submission by Palatine Energy Pty Ltd to the WA State Government Inquiry into the use of hydraulic fracture stimulation (fracking) for onshore petroleum exploration or development in Western Australia

On 21 September, 2017, Dr David Falvey, Managing Director of Palatine Energy, submitted a preliminary comment to the Government very soon after the Inquiry was first announced, and prior to the call for submissions. This present Submission will attempt to summarise the position of the senior management of the company, but does not necessarily represent the views of any of Palatine's partners, sponsors, or its contractors. The author is professionally qualified to make the statements in this Submission, as indicated by his work experience and research engagement over the last 46 years, summarised in Annex 1.

Background and Summary Conclusions

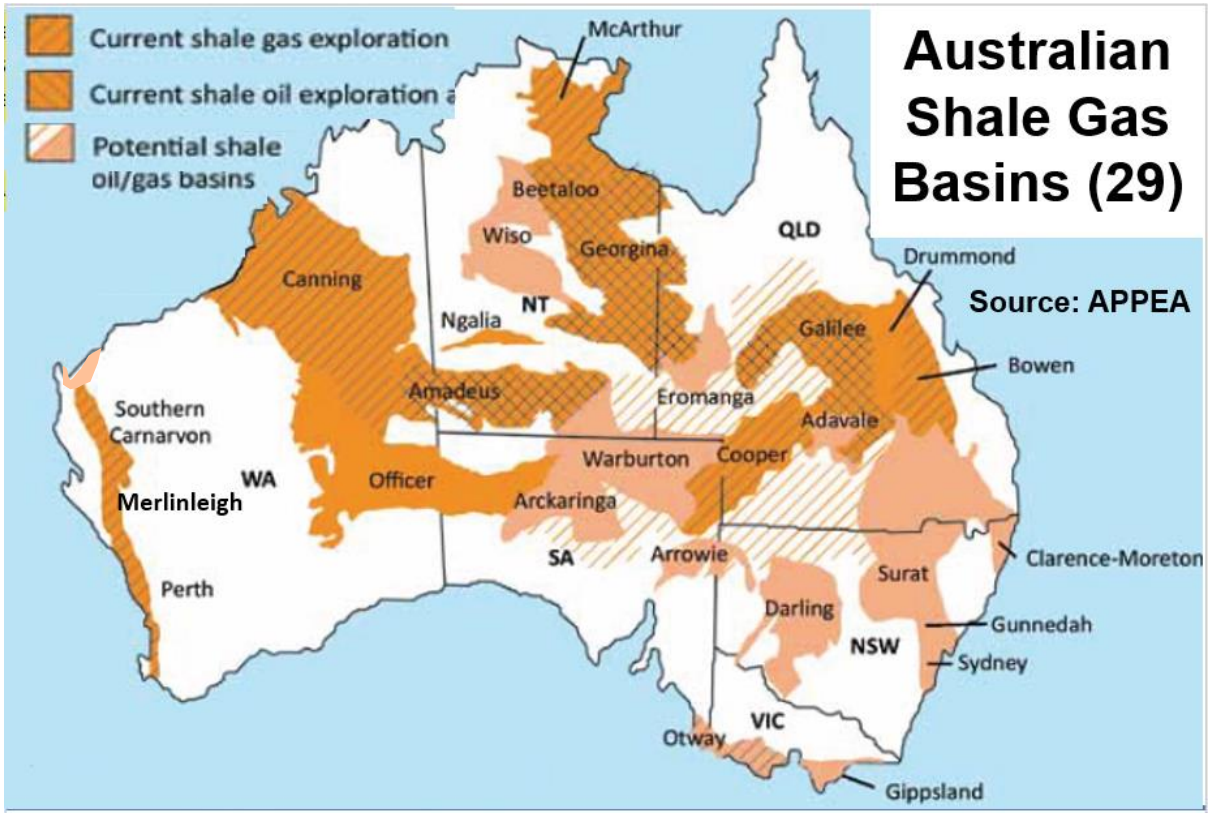
Palatine Energy Pty Ltd has an interest in the outcome of the current inquiry:

- Palatine has two Petroleum Exploration Permit Applications in Western Australia, and an interest in a third:
  - STP-EPA-0127 is in the North Perth Basin and is held solely by Palatine;
  - STP-EPA-0118 is in the Western Officer Basin and is a joint venture in which Palatine holds a 50% interest; *and*
  - STP-EPA-0071 is also in the Western Officer Basin and held by Australian Petroleum Portfolio Pty Ltd, a company in which Palatine holds a 50% interest.
- Liberty Petroleum Corporation has an option to acquire STP-EPA-0071 and STP-EPA-0118 upon grant of the exploration titles.
- All three areas have an as yet unknown petroleum potential, but by comparisons with analogue basins and based on geological/resource settings elsewhere in Australia and overseas, all are believed to be prospective.
- All three have conventional plays, as well as unconventional prospects.
- Palatine is firmly of the view that our continued interest and pending investment by partners in all three areas is based on them being available for unconventional, as well as conventional exploration and possible development.
- Too little ***definitive*** geological information exists across most of these basin areas prior to modern exploration, to arbitrarily preclude as yet unforeseen plays and potential styles of hydrocarbon investigation and testing;
- In taking this position, we accept that rigorous environmental protections will need to be in place, including:
  - Best practice oilfield engineering standards, aimed at well integrity, environmental and human safety – triple steel casing; tested cement barriers; blowout preventers; surface spill mitigation; etc.
  - A world-class regulatory regime, seamlessly encompassing conventional, as well as unconventional exploration and development processes.
  - Company, contractor and regulatory personnel qualifications and continuing training to the highest standards.

WA Onshore Petroleum Resources – Current Assessments

Shale gas development is currently restricted to onshore sedimentary basins – for purely economic reasons. Western Australia's onshore Canning, Perth, Carnarvon (north & south), Merlinleigh, western Amadeus and Officer Basins have all been identified by Australian explorers (summarised by APPEA, on the map below) as being potentially prospective for shale and tight gas. The six WA basins – embracing an area of about 900,000 square kms - are about a third of all of WA land area, which, of itself is just over a third of the Australian continent onshore.

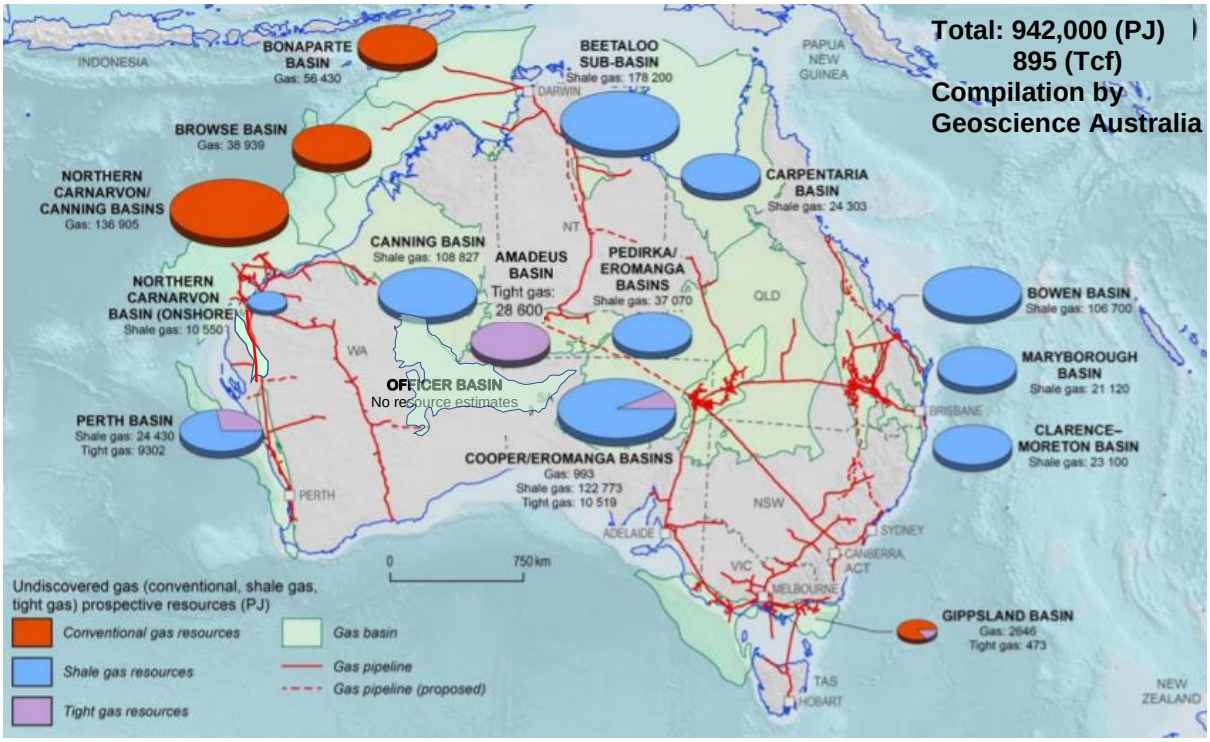
- *Most of these six basins are generally under-explored in a conventional sense, and all are virtually unexplored from an unconventional perspective;*
- *As far as the industry is concerned, generally, and in the professional opinion of Palatine's geoscientists, all are to some degree prospective for shale gas and/or oil, as shown on the figure;*
- *Palatine believes that all WA basins should be available for exploration and development, subject to special restrictions in areas of intense agriculture and agreed housing density.*
- ***Palatine recommends that none of WA's six sedimentary basin area be pre-sterilised just because the currently understood prospectivity is perceived as "low".***



Last year, Geoscience Australia (a highly professional and scientifically independent Federal agency) estimated the potential for undiscovered gas resources of

Australian Basins. Their (we believe somewhat conservative) estimates for WA basins are summarised on the table and map below:

BASIN	STATE	Conventional	Tight Gas	Shale Gas
Canning	WA	small	*unknown*	108,827 PJ
Perth	WA	limited	9,302 PJ	24,430 PJ
Carnarvon (n'th & s'th)	WA	*unknown*	small	10,550 PJ
Merlinleigh	WA	*Not assessed by GA*		
Amadeus	NT & WA	*unknown*	28,600 PJ	*unknown*
Officer Basins	SA & WA	*Not assessed by GA*		



- This estimate of just three of WA's six basins suggests there may be 180 PJ, or 170 trillion cubic feet (Tcf) in place.
- In its 5 September announcement, the Department of Mines, Industry Regulation and Safety (DMIRS) stated that Western Australia, as a whole, may hold shale gas resources of approximately 34,000 billion cubic metres (Gm^3), or 1200 trillion cubic feet (Tcf).
  - The WA Geological Survey (also a highly professional agency) has estimated 8 trillion cubic metres (280 trillion cubic feet) of potential natural gas from shale and tight rocks in the Canning and Perth basins, alone;
  - To this should be added a recent estimate of 2,600 billion cubic metres (Gm^3), or 90 trillion cubic feet (Tcf) in the Merlinleigh Basin.
  - It should be emphasised that tight gas is also an unconventional resource that still requires some hydraulic fracturing to develop. It is not an "alternative" to shale gas fracking (*eg*, Mereenie Oil and Gas field in the

Amadeus Basin, Northern Territory has been developed through "fracking" for some 35 years – without incident).

- These estimates, whether they prove in the long term to be on the high end, or the low, ***far*** exceed the indicative and/or potential ***conventional*** gas resources of all onshore WA basins.
  - If correct, approximately 7,500 Gm^3, or ***265 Tcf of shale and tight gas are very likely recoverable in WA*** from shale and tight reservoirs;
  - At $8/GJ, this gas is worth about $2.25 trillion! It could yield about $200bn in Royalties directly to State revenues, at least $30bn in Aboriginal "royalties", and many times that to economic activity in WA over the next 50+ years.
  - 265 Tcf of gas would potentially deliver reliable, low emission, baseload power Australia for more than 200 years and leave considerable quantities for export.
  - That Australia-wide potential could be realised with a large diameter pipeline from Karratha to Moomba, eventually eliminating the need to burn coal for base load power generation, and reducing Australia's CO_2 emissions.
- This is not a natural resource to be lightly sterilised on exaggerated and scientifically unsupported claims of environmental impacts, nor a source of wealth generation that Australia can afford to turn its back on.
- It must be emphasised that WA's most optimistic assessment of its ***onshore conventional*** gas resources are not even a close match to the unconventional.

Shale oil and gas thus represents a vast wealth of energy available to the people of WA, and the rest of Australia.

Palatine recommends that WA indicative shale-bound hydrocarbons be made available for exploration and potential development, within scientifically determined and transparently applied environmental regulations.

Shale Gas Exploration and Development

Exploration for shale gas (and oil) resources is essentially the same as for conventional hydrocarbons – it differs only in the method of testing and production:

- Geological, geophysical and geochemical surveys and research, with early stage seismic exploration being the main stage;
- Identification of one or more testable "play concepts" – combinations of hydrocarbon source, generation, migration (if any), and potential entrapment of oil and/or gas;
- Early stage "wildcat" exploration involves drilling an essentially conventional exploratory well, with all the modern engineering practices to ensure integrity and safety, with control of sub-surface fluids (water, oil, condensate or gas);
- Testing, involving many forms of downhole geophysical logging and, if hydrocarbons are detected in a formation, testing to see if they will flow, in a controlled and contained manner, to the surface.

- Hydraulic fracturing may be an option if there is no, or insufficient free flow of hydrocarbons during testing – *ie.* very low permeable reservoirs.
- Flow testing involves collecting samples of flowing hydrocarbons, storing oil and flaring gas (if, practically, it cannot be compressed and stored).

This is followed by economic analysis, which takes into account land access and logistic costs, pipeline installation costs, management costs, cost of investment capital, provisions for land restoration, royalties, taxes (Federal and State) and other entitlements. A decision to proceed with development will depend entirely of an analysis of remaining risk and Project net present value. This process may take anywhere from 8 to 15 years from initial Exploration Permit grant, depending on complexity and scale.

If the Project is declared economically and geologically viable, field development will commence. This will involve tens of production wells in the case of a conventional field development; perhaps 50 to 100 wells, each subject to fracturing, in the case of a tight field development; and a hundred or more "fracked" wells in the shale gas/oil case.

The Environmental Concerns

Palatine does not seek to summarily dismiss environmental concerns expressed by many communities. Potentially adverse issues identified in various fora include perceptions of impacts on:

1. Water, including groundwater;
2. Land;
3. Air quality;
4. Public health; and
5. Community.

Well Integrity is the key issue in respect of safeguarding surface water and groundwater – avoiding the theoretical potential for contamination of surface and freshwater aquifers by both natural and introduced well fluids. The Panel will be familiar with the use of typically triple steel casing and cement (multiple barriers) to isolate the ground surface from freshwater aquifers, from saltwater aquifers, and from hydrocarbon reservoirs in the much deeper geological subsurface. A surface blowout preventer is the final safety barrier. This has been industry standard in well-regulated jurisdictions for at least a decade and has delivered extremely few "cross flow events" in that time – certainly none in Australia involving hydraulic fracturing.

In a study commissioned for the Northern Territory Inquiry into hydraulic fracturing, CSIRO found, based largely on data from the US (where over a million wells have been drilled and "fracked"), that the rate of well integrity failure involving multiple barriers, with the potential to cause environmental contamination is extremely low, *with several studies finding no cases at all*. Further, there were very few single barrier failures observed for wells constructed to prescribed (modern) standards of construction.

Well abandonment (where the wells are decommissioned by being 'plugged and abandoned') is the final phase in the well life cycle. CSIRO found that for shale gas wells abandoned using modern practice, if any of the potential leakage pathways were to develop, the depleted pressure regime would mean that it is highly unlikely that significant fluid flow would occur along the well bore. The small cross-sectional areas and long vertical lengths of the pathways will tend to limit flow. The low permeability of shale gas formations also mitigates the potential for adverse impacts caused by degradation of well integrity post well abandonment.

Shale gas extraction requires the use of large quantities of water, which may be obtained from local surface or groundwater sources, or externally transported to the site. Typical water volumes used are around 1-2 megalitres (ML) for well drilling, and approximately 1-2 ML for each hydraulic fracturing stage. In the US, the most recent long horizontal wells require 30-40 fracturing stages. Shale gas/oil development typically involves 10 – 12 wells drilling from a single "well pad", where all wells and fracks are carried out sequentially. Thus, water is reused, requiring about 20 - 40 ML of storage per well pad for a multi-well pad configuration.

Communities are understandably concerned about the amount of water required for drilling and hydraulic fracturing. However, non-potable, semi-saline water is usually acceptable, and it might be anticipated that this could be extracted from saline aquifers, below fresh groundwater. After appropriate processing – defined by the regulator – waste water can be safely re-injected into saline aquifers at sufficient depth to remain isolated indefinitely from aquifers in use.

The composition of chemicals used in hydraulic fracturing has been highlighted as a source of public anxiety. Such chemicals are added to the frack water to provide lubrication, prevent bacterial growth, maintain and keep open fluid pathways and stabilise the mix. Ultimately, the chemical concentrations are very small and all additives are inert (eg, sand) bio- or geo-degradable. In Australia, declaration of chemicals is mandatory and BTEX prohibited.

Drawing on the modern history of well fracturing in North America (over a million) and more than 1,300 in South Australia's Cooper Basin, there has been no reported evidence of fracturing fluid moving from the fractured zone to near surface aquifers.

Land has been cited as an issue. However, a single production well pad, containing 10 – 12 wells, each with a horizontal stage several kilometres long, radiating out to cover an area of perhaps 10 square kilometres, will have a footprint of typically 2 to 3 hectares while drilling and 1 hectare in production. Even considering the need for an access road that may occupy several hundred hectares, the footprint of production is usually less than ½% of the land area.

Air pollution has been cited as a potential problem. Any leakage of natural gas at the surface, through above ground pipework, carries the same risk as for conventional gas production. It is not unique to shale gas development. A potential problem is road traffic volume. Fracking involve many truck movements and diesel operated

compressors immediately before, during and after fracking. This is distinct from the levels of diesel exhaust that might arise during conventional operations. It would not be unreasonable to limit such heavy traffic from areas around habitation or immediately adjacent to sensitive crops. Palatine suggests a 500 metre exclusion zone, noting that this need not preclude directional drilling more than, say, 300 metres beneath such properties.

Seismic activity has also been mentioned as a concern. It is true that fracking generally causes micro-seismic events at, and around the part of the wellbore that is being fracked. The vast majority of such "mini-earthquakes" have a magnitude of less than 2.5 to 3 on the Richter Scale, and are therefore at the threshold of human detectability. The ground vibrations are described as less significant than those induced by a heavy truck driving past. Very occasionally, events up to magnitude 5 have been noted, but these are due to rupturing at or near a natural fault zone, caused by either fracturing or high pressure subsurface waste water disposal. Palatine suggest such events can be avoided by fracturing or fluid disposal more than 500 metres from any identifiable fault, and that the regulator require an analysis of all available seismic data at and around the well.

Public health issues are beyond the expertise of Palatine principals, but we would suggest that the concerns cited in the United States seem to relate to road traffic, rather than fracking, *per se*. Note our suggesting of limiting traffic in areas of habitation and intense agriculture.

There is, importantly, the question of "community impact". Again, the authors of this Submission are not sociologists, but the experience in the US is that employment opportunities and "royalties" do make a big impact on quality of life improvement in relatively poor rural communities. We note that the Shires of Warburton (Western Officer Basin) and Mullawa (North Perth Basin) are amongst the two regions with the lowest per capita income in Western Australia.

Some External Evidence

Geological science, drilling engineering and fracking technology is evolving and applications are widening.

a) According to the United States Geological Survey (USGS), "Changes in technology and industry practices, combined with an increased understanding of the regional geologic framework, can have a significant effect on what resources become technically recoverable,"
b) A new report from the United States Geological Survey this year found that fracking in the Eagle Ford, Fayetteville, and Haynesville shale formations in Arkansas, Louisiana, and Texas are ***not*** the source of benzene or methane contamination in drinking water.
c) The USGS also confirmed the magnitude of the resource in the Haynesville Formation. Spanning southwestern Arkansas, northwest Louisiana, and East Texas, it alone contains an estimated 1.1 billion barrels of oil, 195.8 trillion cubic feet of natural gas, and 0.9 billion barrels of natural gas liquids.

d) Fracking technology continues to advance. Already, a Canadian company, GasFrac, uses a gel made from propane—a hydrocarbon that's already naturally present underground—and a combination of what it says are relatively benign chemicals, such as magnesium oxide and ferric sulphate, a chemical used in water treatment facilities. Over the past few years, GasFrac has used the process 2,500 times at 700 wells in Canada and the United States. Another company is developing an almost waterless fracturing technology, using limited explosive approach, which focusses the fracture zone much more precisely and uses very little water or heavy equipment.

e) Last year, Apache, a Houston-based oil and gas explorer and producer, announced it would switch to powering an entire fracking job with engines using natural gas. This would substantially reduce air quality issues around drilling and fracking locations.

f) Fracking is not just essential to the new wave of hydrocarbon recovery. It is also essential in geothermal energy development. Geothermal energy is the nearest thing to providing a base load supply using renewable energy sources

g) As well as very low porosity/permeability oil and gas reservoirs, fracking can be also applied to the development of groundwater from tight aquifers, After all, "fracking is no more than creating artificial or synthetic fluid pathways in the subsurface in order to bring those fluids to the surface. Indeed, fracking has been used in California during its recent drought to create permeability in water bearing sands to increase waterflow. This has provided water for livestock, without apparent environmental damage or impacts on animal or human health.

Suggested Approach

Like all ground-breaking technologies, this one has its advocates and its opponents. The advocates see wealth generation; the opponents see greenhouse gases and "global warming". This does not really differ from the debate, almost a hundred years ago, about commercial air travel, to cite a pertinent example. Put simply, Australia has an excellent and safety commercial aviation sector for three reasons:

- Best practice and continuous improvement in aeronautical engineering standards and certification by civil aviation authorities.
- A world-class regulatory regime, seamlessly encompassing all aspects of air safety and operation.
- Flight, cabin and ground crew, training and discipline to the highest standards.

These are, in essence, the same three factors that we cited in the Background and Summary Conclusions, on page 1: *engineering; regulation and training*. Just as the implementation of these standards made air travel safe, so it can with the use of hydraulic fracture stimulation in oil and gas exploration and development.

The Board of Palatine believes that adoption of an **engineering; regulation and training** mantra across WA should embed science and engineering evidence on hydraulic fracturing and take on board the experiences and regulatory frameworks that apply in jurisdictions that are seeing safe and economically beneficial shale gas/oil developments.

Dr David A Falvey BSc, PhD, DSc, FGS
Managing Director
Palatine Energy Pty Ltd

19 March, 2018

Annex 1: Basis of this Submission

This submission was prepared by Dr David Falvey BSc, PhD, DSc, FGS, Managing Director of Palatine Energy, and is authorised by the Board. Dr Falvey is qualified to make this submission based on his scientific and technical background in resource geoscience since 1972:

- **Exploration Geophysicist, Shell Development Australia (1972-1974)**
  - As a member of Shell's North West Shelf Exploration Team
- **Lecturer/Senior Lecturer in Geophysics, University of Sydney (1974-1982)**
  - Covering exploration geophysics, basin analysis, marine geophysics and plate tectonics
- **Chief, Division of Marine Geosciences and Petroleum Geology, Australian Bureau of Mineral Resources (1982-1989)**
  - Established a national program of marine geoscience research and petroleum resource evaluation, known as the Continental Margins Program
- **Associate Director, Australian Geological Survey Organisation (AGSO; 1989-1994)**
  - Managed the integration of a national programs of research, onshore and offshore basin analysis, database development, advice to the Federal Government on the administration and management of exploration and evaluation of petroleum resource potential, nationally.
- **Director, Ocean Drilling Programs (ODP), Joint Oceanographic Institutions, Inc; Washington, DC (1994-1997)**
  - Prime contractor to US National Science Foundation to deliver *JOIDES Resolution* ocean drilling and logging research programs
- **Executive Director, British Geological Survey (1998-2006)**
  - Geoscientific mapping of the UK, archive & 3D data compilation for all UK geoscience data, contract overseas surveys & research, advice to UK Government on onshore/offshore exploration– recently on unconventionals.
- **Executive Director, Australian Research Council (2006-2008)**
  - Management of physics/chemistry/geoscience sector, plus the oversight and management of all ARC research centres.
- **Managing Director, Research Connect Pty Ltd (from 2008)**
  - Research Connect is a consulting organisation, whose focus includes global energy and hydrocarbon exploration.
- **Managing Director, Tamboran Resources Pty Ltd (2009 - 2011)**
  - Tamboran is an unconventional oil and gas explorer with interests in Australian onshore basins, particularly the Beetaloo Basin, Northern Territory.
- **Managing Director, Palatine Energy Pty Ltd (from 2011)**
  - Palatine is a small-scale, mainly unconventional oil and gas explorer with interests in Western Australian and Chilean onshore basins.