

WESTERN AUSTRALIA'S DIGEST OF PETROLEUM EXPLORATION, DEVELOPMENT AND PRODUCTION

PETROLEUM

IN WESTERN AUSTRALIA

MAY 2017



Contents



Photo © Karl Schwerdtfeger

Waitsia Gas Project – Stage 1A – Xyris Production Facility,
Shire of Irwin, Western Australia

ARTICLES

- 03** Executive Director's message
- 05** Director's message
- 07** Revision of Resource Management and Administration Regulations
- 08** A brief overview of petroleum activities in Western Australia in 2016
- 12** State areas released for petroleum exploration May 2017
- 15** Canning Coastal seismic survey – an overview of the Canning Basin, Western Australia
- 18** GSWA's innovative Digital Core Atlas
- 20** New Paleozoic book
- 22** GSWA's historical Paleontology Reports now available online
- 25** An overview of underground gas storage in Western Australia
- 27** Tubridgi Gas Storage Agreement approved by Minister

- 28** Grant of titles
- 32** DMP community engagement in the Kimberley
- 34** Expansion of the Perth Core Library
- 36** Departmental integration under AS/NZS ISO 9001
- 38** Well integrity in Western Australia
- 44** The 1920s oil boom in Western Australia

PETROLEUM STATISTICS AND TITLES TABLES

- 48** Table 1. 2015 Production by field and cumulative production from 1 January to 31 May 2015
- 49** Table 2a. Petroleum reserves and resources estimates in WA jurisdictions (SI units, valid as at 31 December 2015)
- 49** Table 2b. Petroleum reserves and resources estimates in WA jurisdictions (Imperial units, valid as at 31 December 2015)
- 49** Table 3. Petroleum wells in Western Australia – onshore and State Waters 2016 calendar year
- 50** Table 4. Well activity approvals
- 51** Table 5. List of petroleum titles and holders in Western Australian jurisdictions as at 9 February 2017
- 56** Key Petroleum Contacts

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Cover: Waitsia Gas Project – Stage 1A – Northern Hub, Shire of Irwin, Western Australia © Karl Schwerdtfeger

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Photo Courtesy of Kimberley Oil

WESTERN AUSTRALIA

Opportunities to Explore – BIDS INVITED FOR ACREAGE

PETROLEUM ACREAGE

Onshore Canning Basin

Interest in the Canning Basin has revived significantly in recent years, with new oil plays discovered at Ungani 1 and Ungani Far West 1. There are five release areas in the central and southern Canning Basin. The southern two release areas are mainly in the Kidson Sub-basin whereas the northern three release areas are mainly in platform and terrace tectonic elements.

Release area size ranges from 5324 km² to 6667 km². These areas may have subsalt (Ordovician) and suprasalt (Devonian) plays.

'The best remaining frontier prospects lie ... in older basins with a high preservation potential such as intracratonic basins with evaporite seals.'

Duncan S Macgregor, BP, 1996

**Bids close on Thursday 1 February 2018.
Applications can only be made online.**

Acreage release information will be available from the department's website from the gazettal date of 16 May 2017:
www.dmp.wa.gov.au/acreage_release

Release information includes prospectivity of release areas and of the Canning Basin, available data listings, work program bid assessment guidelines, land access and environment considerations, and instructions regarding how to make a valid application for an Exploration Permit. This information will also be available on a USB.

GEOHERMAL ACREAGE

Acreage is available for the whole of the State not covered by permits or applications. Application is by a Geothermal Special Prospecting Authority (GSPA) with Acreage Option (AO).

Companies are invited to apply for areas with sizes up to 160 5'x5' graticular blocks.

Companies interested in geothermal acreage are allowed to bid for multiple areas and are expected to drill at least one well during the first two years of obtaining a geothermal title.

Geothermal acreage information is available from DMP on the web at:
www.dmp.wa.gov.au/acreage_release

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Executive Director's message

Jeff Haworth
Executive Director
Petroleum Division



As we enter the third consecutive year of lower oil prices, the 2014 cycle is now the longest cycle of depressed oil prices since the March 1986 cycle. This is not a very satisfying statistic for the industry and most pundits do not anticipate a recovery any time soon.

Of course you didn't need to hear that, however, it is important to understand that any slump in the price of oil has a consequential slump in exploration funding. Statistics show that recovery in exploration activity is usually 18 months after the recovery in oil prices. By this measure, even if the oil price were to recover in the short term, the low level of exploration activity we saw in Western Australia during 2016 will likely continue through 2017.

I spent some time in Pennsylvania, Alberta and British Columbia, during October 2016 meeting with regulators, local government, industry, and business organisations. The purpose of the trip was twofold, I was requested to present at the Canadian Global Exploration Forum in Calgary to present an overview of the state of the petroleum industry and exploration opportunities in Western Australia. I was also invited by the State of Pennsylvania and the Province of British Columbia to share insights into the regulation of the onshore petroleum industry,

specifically around shale gas. This was a very educational trip which gave me insights into how the industry was regulated in these jurisdictions and some of the issues they have.

Alberta is a mature oil and gas province with a total of 450,000 petroleum wells. Of this number, 174,000 are active and 170,000 have been hydraulically fractured. The oil sands deposits in the north of the province near Fort McMurray are massive, 27 billion kilolitres (170 billion barrels). Alberta also contains 6.2 trillion cubic metres, Tm^3 (220 trillion cubic feet, Tcf) of conventional gas and an estimated 96.4 Tm^3 (3405 Tcf) of unconventional gas resources. Alberta's oil and gas industry is regulated by the Alberta Energy Regulator (AER), which has a similar regulatory regime as Western Australia. The AER takes stakeholder engagement seriously and employs 120 people dedicated to this activity.

British Columbia is less mature than Alberta with around 25,000 unconventional wells in the province. LNG export of Canadian gas, through facilities yet to be built in British Columbia, is the main focus of attention for the province. The oil and gas industry is regulated by the British Columbia Oil and Gas Commission, which has similar powers as the AER in Alberta.

My time in Pennsylvania was very enlightening and meeting with local government officials and townsfolk gave me another perspective on the industry, especially on how it has developed since 2004 in that State. It was also notable that all the issues around stakeholder engagement, community outreach and strong regulation we have experienced in Western Australia are common throughout all the places I visited.

Among the biggest concerns landowners had were around the amount of traffic, road conditions, road safety and local jobs. This was made clear when one of the locals said, "In the beginning, Texans and Okies (Oklahomans) just rode into town and started drilling holes and did not understand our culture or way of life". He went on to say that Pennsylvanians were not convinced when oil companies said, "Trust us, we know what we're doing" as that was what the coal miners said a century before, and they are now living with the legacy of that industry. At that time, 2004, Pennsylvania was in a depression with the closure of steel mills, coal mines and a depressed agricultural industry, so watching "foreigners" coming in with no job opportunities for the locals was not well received.

There was a moratorium placed on the shale gas industry in 2004, while

the Pennsylvania Department of Environmental Protection (DEP) introduced new laws to govern the industry and the US Environmental Protection Authority released its 2004 report on hydraulic fracturing.

Since then, through community outreach programs by industry and other initiatives by industry, local interest groups and DEP, shale gas and oil drilling has recommenced and the public is more comfortable with the process and how it works. In the decade since 2004, there have been 14,000 shale wells drilled in Pennsylvania, worth approximately US\$140 billion in drilling expenditure alone.

In Western Australia, over the same period, a total of 12 wells were

drilled exploring for either shale or deep tight sands, and had hydraulic fracture stimulation performed on them with varying results.

I mention this comparison to emphasise that Western Australia is very much at the early exploration phase of shale and tight gas and with the current robust regulatory framework in place, Western Australia is in a far stronger position than Pennsylvania was in 2004.

Throughout 2017, DMP will remain committed to meeting with local government representatives and engaging with stakeholders to inform the public on how the petroleum industry is regulated, and to answer any questions or concerns the public may have on this industry.



Jeffrey Haworth, Executive Director Petroleum with local government and business officials in Pittsburgh, Pennsylvania, USA

Director's message

Denis Wills

Director Petroleum Operations
Petroleum Division



2016 was a challenging year and I believe that 2017 will also be a challenging year, a year in which we all will need to remain focused on and be proactive in dealing with the risks we face.

In the last few editions of Petroleum in WA I have touched on compliance and stakeholder engagement, two key issues for the Department of Mines and Petroleum (DMP), and again in this issue I would like to take the opportunity to address these topics again.

In addition to these themes, I would like to discuss the 2017 acreage release and the Petroleum Division's continuing development of explanatory notes and guidelines to ensure the processes we apply in assessment and the criteria used are transparent and understood.

At the very top of the compliance ladder from a registered holder's perspective there is a need to comply with a Well Management Plan, Field Management Plan, Environment Plan and the Safety Case. From the regulator's perspective, it is ensuring through the assessment process that these plans are acceptable based on the "As Low As Reasonably Practicable" (ALARP) principle, and also through inspections ensuring that what was said would be done, is actually happening.

I have always considered that an important element in the compliance chain is the need to have knowledgeable and experienced people. If I may reflect on this broader aspect of compliance, note that the year 2016 was the anniversary of a number of important major accidents (not necessarily oil and gas related) going back as far as Oppau in Germany some 95 years ago. These anniversaries are important in that these major accidents helped set some of the principles by which we manage or mitigate risk within the broad spectrum of industries today. However, there is a view by some engineering professionals that there is still an indication from some present day incidents that lessons that should have been learned have not. The same key factors continue to be listed as causes in these incidents. These include inadequate design, poor identification of hazards and appropriate mitigation measures, poor maintenance and inspection, inadequate consideration of human factors and inadequate inspection and enforcement by public authorities (regulators). One observation that can be made in looking back at these major incidents is that many took place before today's engineers and technicians entered the profession or were even born.

As such, an important consideration in regard to this broader aspect of compliance is recognising the experience of individuals and ensuring, where necessary, adequate supervision, so that they and others do not have to learn through personal and sometimes tragic experience. There is a need for us all to recognise, acknowledge and mitigate this risk, whether we are the registered holder or the regulator.

DMP will continue to focus on site inspections and compliance this coming year and will be taking a stronger stand on enforcement.

Stakeholder engagement also remains a primary area of effort for the Petroleum Division in this coming year. Although the degree of activity in the industry may not seem to warrant such ongoing effort, our view is that not to engage with the community on a continuous basis would put at risk the good work that has helped to factually inform the community. That work has also established the credibility of DMP as a regulator that respects the importance of the concerns and needs of the community.

For the industry to take a break from this engagement there is the risk of the perception developing that industry only talks with the community when it wants something

– to drill a well, build a production facility. Such a perception, I believe, would be detrimental to the long-term relationship between industry and community. Industry also runs the risk, through not having continuous engagement, of not being able to respond in a timely manner to prevent negative sentiment on exploration developing from misinformation circulating within a community.

As part of Petroleum Division's continuous improvement program we have been developing new policies covering petroleum exploration titles. In association with the petroleum exploration titles

policy, we are developing a guideline to cover a Special Prospecting Authority (SPA) and an SPA with an Acreage Option. Also on the horizon in 2017 is a revision to the Western Australia's Petroleum and Geothermal Explorer's Guide and what might be called a 'lite' revision to the Resource Management and Administration Regulations 2015.

At the APPEA conference in May, we will be announcing an acreage release (Round 1) which will be focused on the Kimberley region. Again as part of our continuous improvement program, we have just released a new guideline entitled 'WA Petroleum Guideline – Criteria

for Assessment'. This new guideline replaces the old guideline 'WA Petroleum Guidelines for Acreage Release – Criteria for Assessment' and also incorporates guidance in relation to drilling reservations and transfers to become a registered holder of a petroleum title in Western Australia.

Connected with the acreage release process we are finalising a five year plan to better define future acreage release areas. This strategy will provide industry with a clearer picture of areas the State is considering for competitive bidding, resulting in a transparent and more streamlined approach to title matters.



DMP officer engaging with a member of the community

Revision of Resource Management and Administration Regulations

Eric Cormack

Senior Legislation and Policy Officer
Petroleum Division



Petroleum Division inspector on a well integrity inspection in the northern Perth Basin

The Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 [PGER(RMAR) 2015] and the Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015 [PSL(RMAR) 2015], collectively, 'the Regulations', came into operation on 1 July 2015.

The Regulations provide an objective based, risk managed approach to the exploration for, and production of, petroleum and geothermal energy resources and cover a range of resource management and administration matters including well management plans for the approval of all drilling activities; notification and reporting of discovery of petroleum; and field management plans for approval of petroleum recovery.

The Regulations also:

- provide a framework for the collection, retention and dissemination of petroleum and geothermal energy resources data and the efficient management of data confidentiality
- ensure that petroleum and geothermal energy resource activities are carried out in accordance with good industry practice that reduces the risk of aquifer contamination and are compatible with optimum long-term recovery of the resource.

The revision of the Regulations is intended to pick up improvements and enhancements required to refine the existing regulations from the lessons learned from more than 21 months of application of the Regulations. Wholesale changes will not be required to the structure or content of the Regulations as the amendments will "fine-tune" or make corrections to help better define what is required or add provisions that were not initially included.

Amendments will also be made to the release of well information regulations in response to recommendation 2 of the Legislative Council Standing Committee on Environment and Public Affairs report No. 42, "Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas", which was tabled in the Legislative Council on 16 March 2016.

The Committee recommended that regulation 83 of the PGER(RMAR) 2015 be amended and subregulations 83(4) and (5) be deleted to ensure consistency with Government's objectives on openness and transparency. Regulations 83(4) and (5) provide that a person (usually a registered holder) may request that documentary information provided to the Minister is permanently confidential information on the grounds of being either a trade secret, or would or could reasonably be expected to adversely affect the person's business, commercial or financial affairs.

The deletion of subregulations 83(4) and (5), and the equivalent subregulations in the PSL(RMAR) 2015, will support the Department of Mines and Petroleum (DMP) in moving toward a more transparent approach to the release of information by removing the ability for a person to make a claim against the release of information, and leaving the determination of whether documentary information given to the Minister is permanently confidential solely with the Minister, in subregulation (3).

In keeping with other general themes in the Committee's report, DMP will also amend the release provisions for well information to:

- change well management plans, and any revisions of these, from permanently confidential to immediately releasable
- enable the release of daily well activity reports after two years
- change production data from annual assessment reports from permanently confidential to releasable after one year
- enable the release of monthly production reports after one year.

A short consultation period will be held when a final draft of the revised Regulations has been prepared.

A brief overview of petroleum activities in Western Australia in 2016

Daniel Hearn
Policy Officer
Petroleum Division



Photo © DBP Development Group

Aerial view of TGS 1

Despite the sustained downturn in international oil and gas prices, petroleum activities in Western Australia since July 2016 have been making some headway.

Exploration and appraisal

In the second half of 2016, petroleum operators focused their efforts on well testing and well workovers. No exploration drilling or seismic surveys were undertaken during this period, due to the low oil and gas price.

In July 2016, AWE undertook Diagnostic Fracture Injection Testing (DFIT) at the Waitsia 2 and Irwin 1 wells, located on production licence L1, 17 km east of Dongara. Preliminary results confirm that a high quality conventional system with excellent connectivity exists within the Kingia Sandstone and High Cliff Sandstone. AWE is currently preparing to drill two appraisal wells in 2017. Data from these wells, combined with production data from Stage 1A, will enable the reassessment of Waitsia 2P Reserves in the second half of 2017.

Well testing at Latent Petroleum's Warro field, located on retention lease R 7 approximately 200 km north of Perth, occurred during July 2016 with Warro 4, Warro 5, and Warro 6 having undergone well testing. Data from this activity is now being analysed to gain a

greater understanding of the Warro field. The high gas/water ratio for the field has created technical issues that need to be addressed before further development can occur.

Red Gully North 1, operated by Empire and located on EP 389, 150 km north of Perth, underwent a workover and well test during December 2016 and January 2017. The flow test recorded a gas flow of 0.036 million cubic metres per day, Mm³/d (1.3 terrajoules per day, TJ/d) and 64 kilolitres per day (kL/d) condensate within the C sand zone of the Jurassic Sandstone occurring within the Cattamarra Coal Measures. Empire is now undertaking a detailed review of the test data, which will be followed by a reserve assessment to evaluate the size of the C sand gas/condensate discovery and its potential commerciality.

Recent well testing at Buru Energy's Asgard 1, located on EP 371, 180 km southeast of Derby, has provided additional information confirming the potential for the Laurel tight gas accumulation. During flowback, flow rates of over 0.085 Mm³/d (3.2 TJ/d) to continuous rates of up to 2825 m³/d (0.1 TJ/d) in individual zones were achieved. Analysis of the gas composition from various zones is currently being undertaken.

On 6 November 2016, Whicher Range Energy did not renew its

exploration permit on EP 381 R3, east of Margaret River. The original title for this area was granted in 1993 and has been renewed three times. In November 2014, Whicher Range Energy indicated that the Whicher Range field could be extended further south from petroleum exploration permit EP 408 into EP 381, potentially containing an additional 42 billion cubic metres of gas (Gm³). Current estimates for the Whicher Range field are that it contains between 28–141 Gm³ of gas.

Development and production

In early August of 2016, the first flow of gas from Waitsia 1 and Senecio 3 wells was achieved. The Waitsia field is the largest onshore gas discovery in the past 30 years. The Waitsia 1 and Senecio 3 wells are situated within production licences L 1 and L 2 respectively, located approximately 16.5 km east-southeast of Dongara.

During December 2016, Buru Energy's Ungani Far West 1, which is appraising the Ungani oilfield, remained shut-in for pressure build-up during injectivity testing. Buru Energy is working to restart oil production at Ungani with upgrades to the field's facilities currently being scoped and costed. The field is located in production licence L 20, 97 km east of Broome.

Waitsia Gas Project update

The Waitsia Gas Project is operated by AWE, under a 50–50 joint venture with Origin Energy, on production licences L 1 and L 2. The first commercial gas flow was produced from Waitsia Stage 1A in August 2016.

New infrastructure was installed to connect the Waitsia 1 and Senecio 3 gas wells to the upgraded Xyris Production Facility during Stage 1A. The Xyris Production Facility has now been commissioned with a production capacity of 0.267 Mm³/d (10 TJ/d). Currently 0.224 Mm³/d (8.4 TJ/d) of gas is being delivered to the domestic market via the Parmelia pipeline.

The Senecio 3 well is producing from the Kingia Formation, while Waitsia 1 well is flowing from the High Cliff Sandstone. Both wells have performed better than pre-production expectations. An independent review of well performance has indicated gross 2P reserves of 13.02 Gm³ (487 PJ) of gas, 34% higher than AWE's previous estimate of 9.74 Gm³ (364 PJ) of gas.

AWE has commenced pre-front end engineering design work at Waitsia Stage 2 and undertook a tender

process for Waitsia 2 gas sales. AWE is planning on drilling two new appraisal wells during 2017. Once in full production, the Waitsia Gas Project is forecast to produce approximately 2.67 Mm³/d (100 TJ/d) of gas from approximately 20 wells for 10 years.

Tubridgi gas storage

The Tubridgi gas storage facility will be the largest gas storage facility in Western Australia. It is currently being constructed by DBP Development Group, which is 100% owned by the DUET Group. Gas will be stored in the depleted Tubridgi onshore gas reservoir, which is located on production licence L 9, 30 km southwest of Onslow.

This site occurs in close proximity to the Chevron-operated Wheatstone and BHP-operated Macedon domestic gas production facilities and will be connected to Compressor Station 2 on the Dampier to Bunbury Natural Gas Pipeline, via existing gas transmission lines. The Sino Iron magnetite project will be the foundation customer under a 10 year gas storage agreement.

In December drilling was undertaken at the Tubridgi gas storage facility with the establishment of TGS 1, TGS 3,

TGS 4 and TGS 4A. However, TGS 4 and TGS 4A wells had to be decommissioned because of well integrity issues. Additionally, TGS 1 was perforated and well tested. Tubridgi is a depleted gasfield which produced 1.8 Gm³ (69 PJ) of dry gas between 1991 and 2004. As the field is relatively shallow, sitting at 550 m below the surface, the field requires low injection pressures for gas storage.

Gorgon Project update

The Gorgon Project is located 60 km off the northwest coast of Western Australia and is one of the world's largest natural gas projects. When complete it will contain a three-train 15.6 million tonne per annum (Mt/a) liquefied natural gas (LNG) facility, a domestic gas plant with a capacity to supply 8 Mm³/d (300 TJ/d) of natural gas, and a carbon dioxide injection facility. This domestic gas supply is equivalent to generating enough electricity for 2.5 million households. Gas for the Gorgon Project will be supplied from the Gorgon and Jansz–Io gasfields, located 65 km west of Barrow Island and 130 km northwest of Barrow Island, respectively.



First production from the Waitsia gas project achieved in August 2016



Gorgon Project LNG processing trains at Barrow Island

The Gorgon Project is operated by an Australian subsidiary of Chevron (47.3% interest), in joint venture with the Australian subsidiaries of Exxon Mobil (25% interest), Shell (25% interest), Osaka Gas (1.25% interest), Tokyo Gas (1% interest) and Chubu Electric Power (0.147% interest).

In March 2016, the first LNG shipment from the Gorgon Project left from Barrow Island and was supplied to one of Chevron's foundation buyers, Chubu Electric Power, for delivery into Japan. LNG was produced from the first of the three gas processing trains with the Asia Excellence LNG vessel departing two weeks after the first production of gas.

In December 2016, Gorgon began producing gas for the domestic market and currently supplies an initial 4 Mm³/d (150 TJ/d) of gas. Domestic gas from the Gorgon Project feeds

into the existing Dampier to Bunbury Natural Gas Pipeline.

The first two production facilities at Gorgon are operating near capacity and commissioning for the final train is completed. The Gorgon Project produced its 50th cargo in early March 2017 and is now fully operational. Chevron announced that it had started-up the third, 5.3 Mt/a train on 28 March 2017, ahead of its original schedule.

Works for the Carbon Dioxide Injection Project are continuing, with the first CO₂ injection expected to begin in the second half of 2017. Commissioning of the project is planned to occur following the introduction of gas from the Gorgon field. Approximately 3.4 to 4 million tonnes of reservoir CO₂ will be injected each year, reducing greenhouse gas emissions from the Gorgon Project by approximately 40%.

Wheatstone Project update

The Wheatstone Project is located at Ashburton North, 12 km west of Onslow on the Pilbara coast of Western Australia. The project is comprised of the Wheatstone and Iago fields, an offshore platform, a pipeline to shore and an onshore plant located near Onslow. The onshore plant will include two LNG trains with a combined capacity of 8.9 Mt/a, and a 5.3 Mm³/d (200 TJ/d) domestic gas plant. LNG and condensate will be exported and domestic gas transported via a pipeline to the Dampier to Bunbury Natural Gas Pipeline.

The Wheatstone Project is a joint venture between Australian subsidiaries of Chevron (64.14% interest), Kuwait Foreign Petroleum Exploration Company (KUFPEC) (13.4% interest), Woodside Petroleum Limited (1.46% interest) together with

PE Wheatstone Pty Ltd, part owned by JERA (8% interest). Eighty per cent of the Wheatstone Project's foundation capacity will be fed with natural gas from the Wheatstone and Iago fields, with the remaining 20% of gas being supplied from the Julimar and Brunello fields.

The Wheatstone Project is approaching LNG Train 1 construction completion, with all modules situated on site and final hook-up and commissioning having been commenced. The first LNG from Train 1 is expected in mid-2017 and from Train 2 in late 2017 or early 2018. The Train 2 modules are set on their foundations and installation of piping, electrical and instrumentation is continuing as planned. The drilling campaign for all nine development wells is now complete and ready for the start of production. The hook-up and commissioning activities for the offshore platform is progressing.

The export jetty and LNG loading platform at the plant site are now complete with all LNG Train 1 modules on site with structural, mechanical and piping works currently being undertaken.

Decommissioning

A number of decommissioning activities occurred in the second half of 2016 and the beginning of 2017. During July and August 2016 Quadrant Energy undertook the decommissioning of Chervil 5 and 6 wells, which are situated in the TL/2 production licence. TL/2 is located in the offshore Carnarvon Basin, approximately 40 km north-northeast of Onslow and is operated by Quadrant Energy.

During December 2016 and January 2017, Chevron undertook decommissioning offshore near Thevenard Island. The Ensco 107 jack-up was used for the plugging and abandonment of Cowle 3, Cowle 4, and Cowle 5M, located on TL/4. Chevron will move forward in 2017 to progressively plug and abandon the offshore Roller, Skate and Saladin fields prior to undertaking onshore decommissioning work. The Saladin oilfield was discovered in 1985, with production from Thevenard Island beginning in 1989. The Thevenard project included three Saladin platforms and six monopods associated with the Roller, Skate, Yammadery, and Cowle fields. In December 2013, Chevron applied to decommission the

Thevenard Island fields with production ceasing in January 2014.

AWE's Mount Horner 12 and Mount Horner 14, located 21 km northeast of Dongara on production licence L 7, were decommissioned during December 2016 and January 2017. Mt Horner 12 was drilled and cased in July–August 1992 and produced oil from the Cattamarra Coal Measures. Mount Horner 14 was drilled and cased in November–December of 1993 and, like Mt Horner 12, targeted the Cattamarra Coal Measures. In January of 2011, the Mount Horner oilfield was shut-in and put into care and maintenance with the field being deemed uneconomic.

AWE's Dongara 12, located approximately 10 km east of Dongara on production licence L 2 underwent preparation work for decommissioning during December 2016 and January 2017. Natural gas was first produced from the Dongara gasfield in October 1971 with Dongara 12 being drilled in 1969 targeting the Dongara and Wagina Sandstones. After a period of steady production, the well was shut in due to an influx of formation water. Efforts to recommence production were unsuccessful and the decision was made to decommission the well.



Wheatstone LNG plant site and loading platform

Photo © Chevron Australia

State areas released for petroleum exploration May 2017

Richard Bruce

Exploration Geologist
Petroleum Division



Photo © Kingsway Oil Ltd

Aerial view of Sally May 1 located in L17-1

The Department of Mines and Petroleum (DMP) continues to promote the petroleum potential of Western Australia's vast sedimentary basins using a specific area release system. On 16 May 2017, DMP plans to gazette a total of five onshore release areas in the central and southern Canning Basin (Fig.1). Release area size ranges from 5324 km² to 6667 km². This gazettal is timed to coincide with the 2017 APPEA Conference in Perth.

Canning Basin

Interest in the Canning Basin has revived significantly in recent years with new oil plays discovered at Ungani 1 and Ungani Far West 1. Canning Basin oil may be trucked to ports in the north of the State for shipment to refineries in southeast Asia or trucked to the Kwinana oil refinery in the south of the State.

The northern three release areas, L17-1 to -3, are contiguous and collectively cover 17,664 km² (Fig. 2). These areas are accessible from Broome via the Great Northern Highway and extend from the southeastern Broome Platform eastward, across the northwestern Crossland Platform and the central Barbwire Terrace, and into the Gregory Sub-basin. These are among the best explored regions of the Canning Basin, where 15 wells have recorded hydrocarbon shows, including

Looma 1, Acacia 2, Mirbelia 1 and 2 and Sally May 1.

Release areas L17-1 to -3 are considered prospective for both subsalt (Ordovician) and suprasalt (Devonian) plays. A new Devonian play has been proposed for the Barbwire Terrace, where a series of *en echelon* wrench-related anticlines have been interpreted from seismic data.

The southern two release areas, L17-4 and L17-5, collectively cover 12,905 km² and are regarded as frontier acreage, with much less on-ground exploration than the northern three release areas (Fig. 3). However, couldn't there be room for a large discovery? Salt diapirism may provide traps in areas of the basin that lack major block faulting.

"The best remaining frontier prospects lie ... in older basins with a high preservation potential such as intracratonic basins with evaporite seals."

Duncan S Macgregor, BP, 1996

Release areas L17-4 and L17-5 are contiguous and lie just south of the three northern release areas. These two release areas are accessible via the Kidson Track, the Kiwirrkurra Road and the Canning Stock Route and extend across the northern flank of the Kidson Sub-basin eastward, over the southwestern flank of the Crossland Platform. The closest

well to the southern release areas is Gibb-Maitland 1, drilled during December 2012. In the Kidson Sub-basin there are salt-related plays (including sub-salt Ordovician) that have hardly been tested.

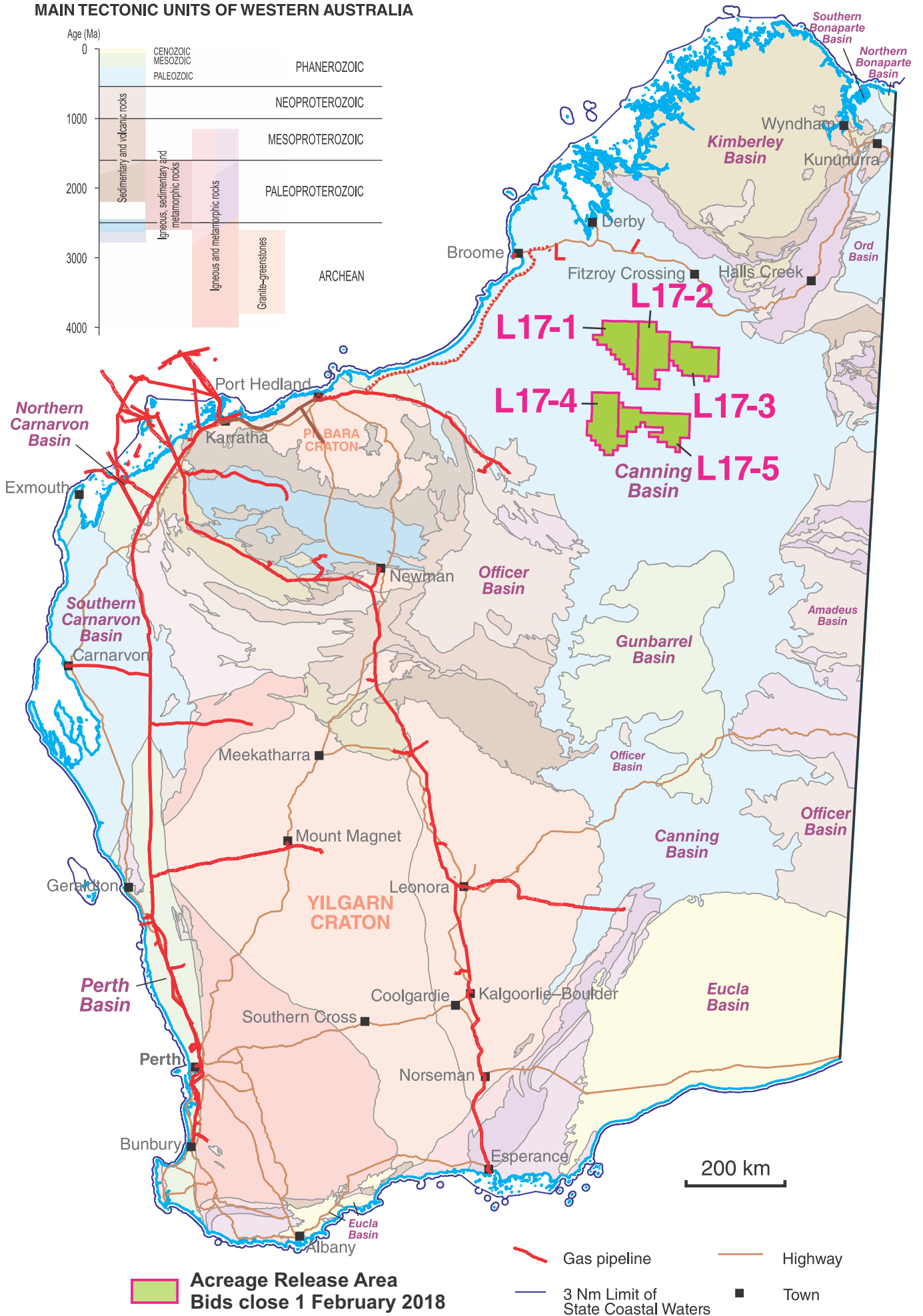
Release information

This information includes prospectivity of release areas, a Canning Basin summary, available data listings, new bid assessment guidelines, land access and environment considerations, schedule of fees and information regarding how to make a valid application for an Exploration Permit. More detail on the prospectivity of the release areas has been described by the Geological Survey of Western Australia.

Release information is available on USBs for distribution at events and meetings. The most current information is available on the Department's website at: www.dmp.wa.gov.au/acreage_release

Work program bids for the release areas close at 4pm Australian Western Standard Time on Thursday 1 February 2017 and applications can only be made online.

MAIN TECTONIC UNITS OF WESTERN AUSTRALIA



RB131b

26/04/17

Figure 1. May 2017 State petroleum release areas

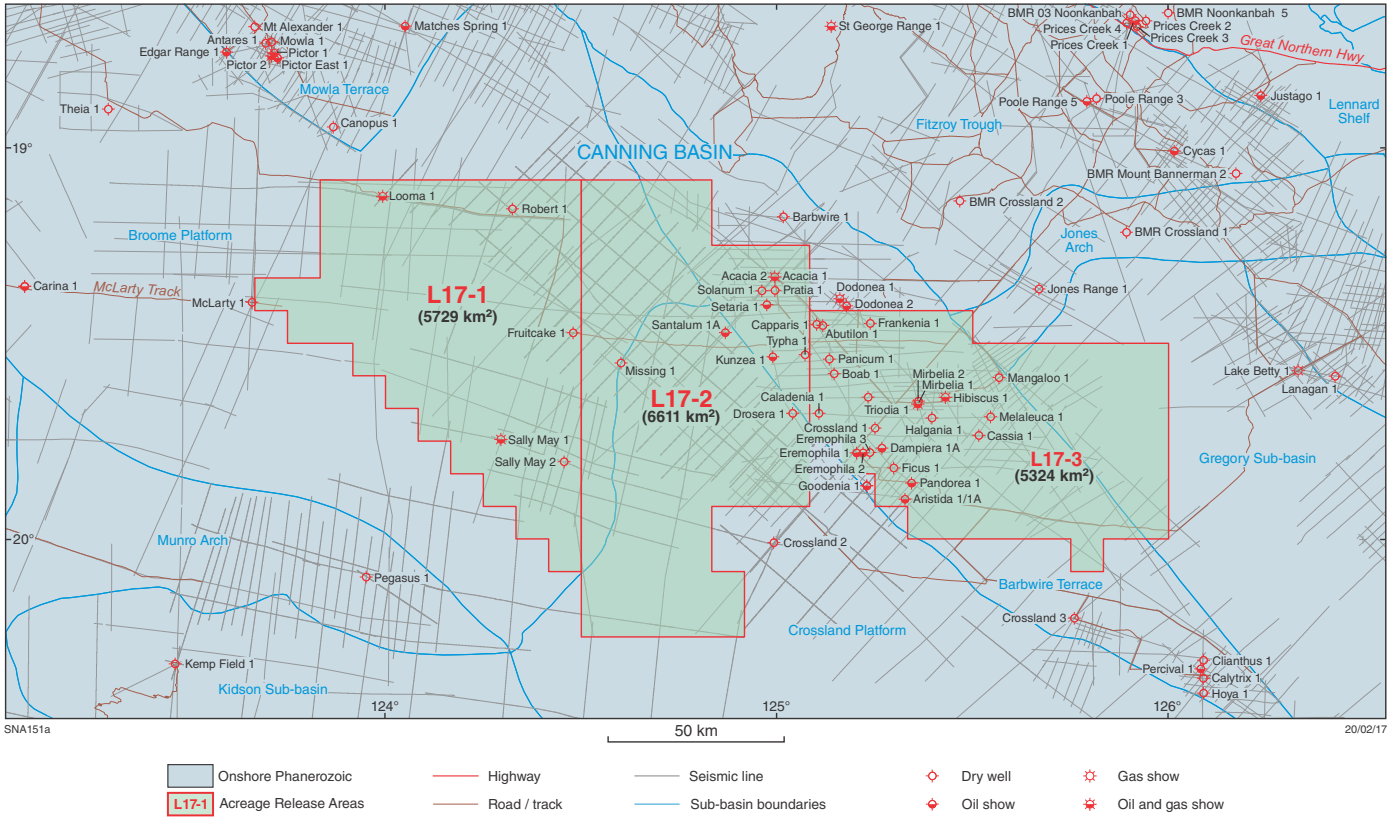


Figure 2. Location of release areas L17-1 to -3 in the Canning Basin

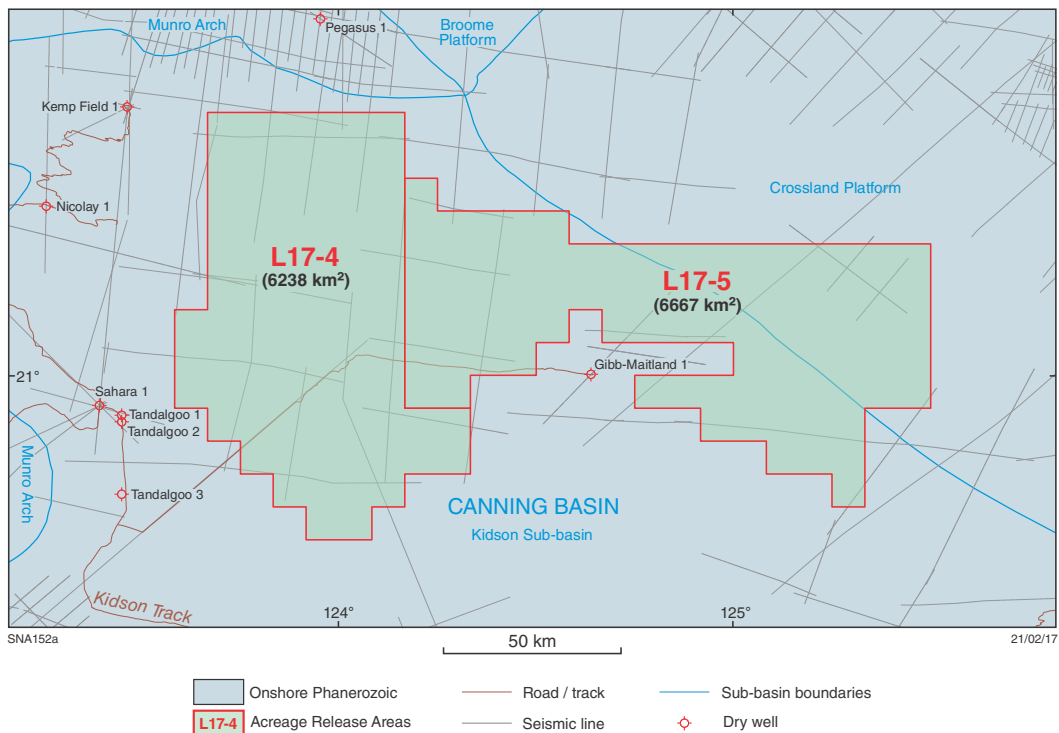


Figure 3. Location of release areas L17-4 and L17-5 in the Canning Basin

Canning Coastal seismic survey – an overview of the Canning Basin, Western Australia

Alex Zhan
Senior Geophysicist
Resources, Geological Survey of Western Australia

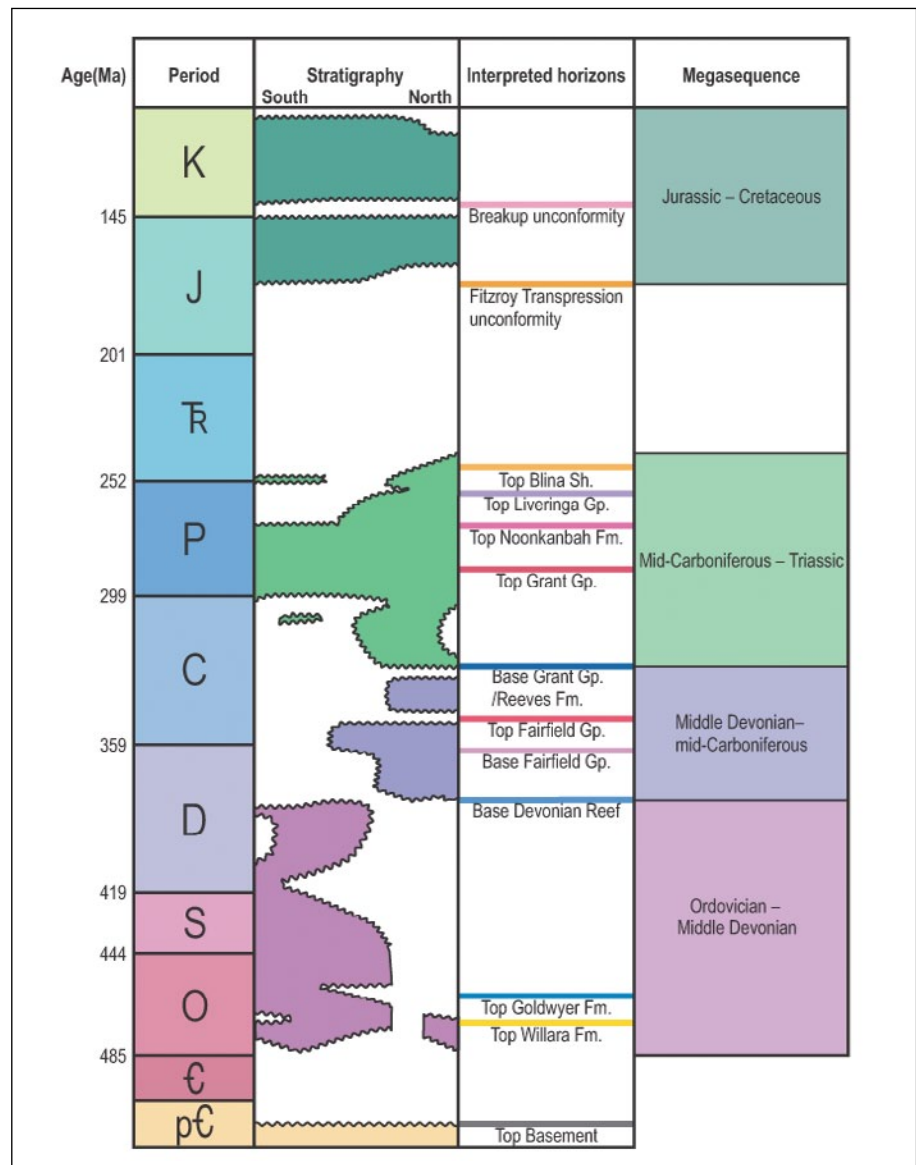


Vibroseis truck on the Canning Coastal seismic survey

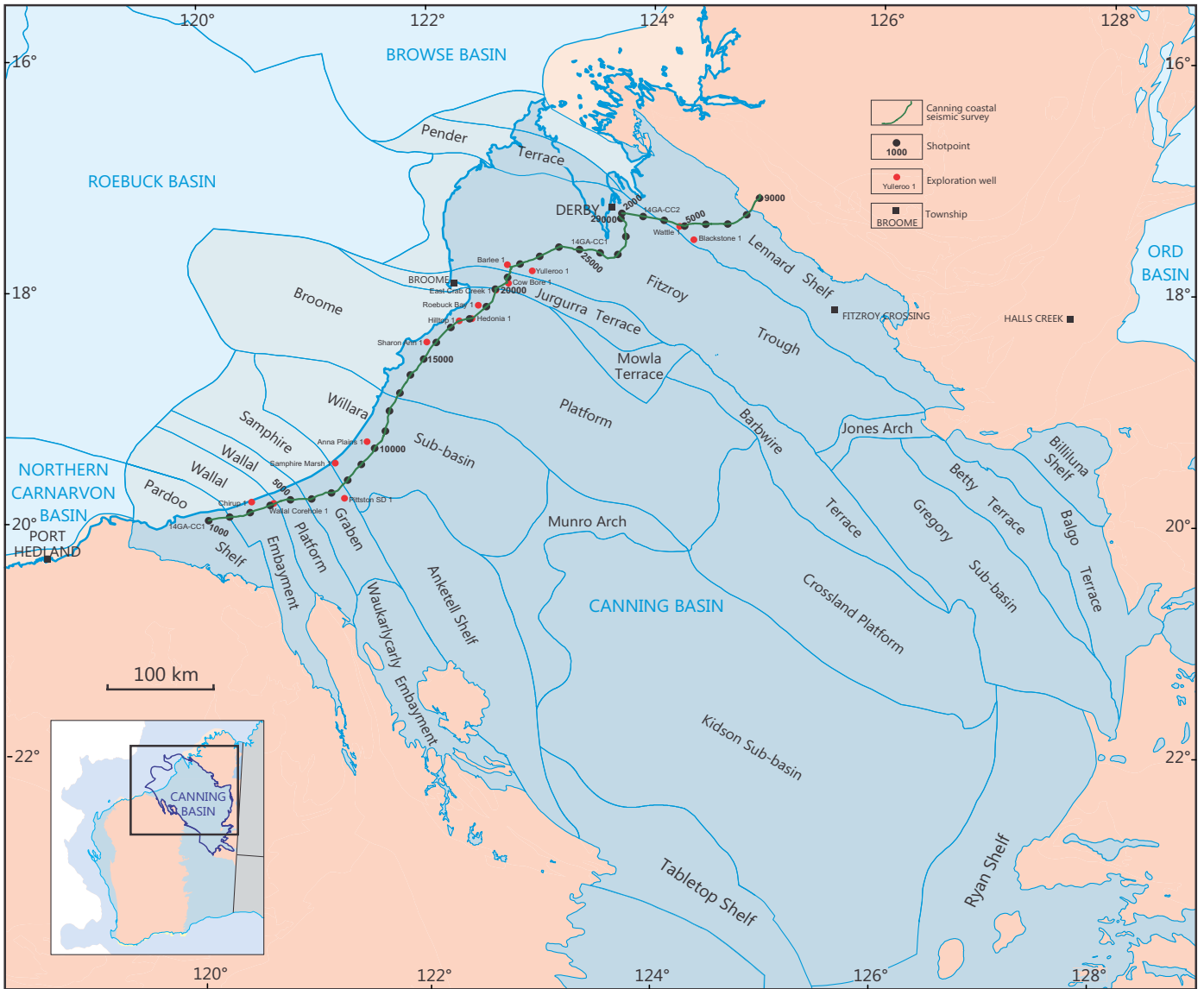
In order to investigate the tectonic architecture and stratigraphic distribution of the Canning Basin, the Geological Survey of Western Australia (GSWA) in collaboration with Geoscience Australia (GA) acquired a deep crustal seismic survey across the basin in 2014, from Pardoo Roadhouse on the North West Coastal Highway to Stumpy's Jump-up on the Gibb River Road. This project was funded by the Western Australian State Government's Exploration Incentives Scheme (EIS). The seismic section has been interpreted and this is expected to be released in mid-2017 as GSWA Record 2017/5.

Regional observations of the four megasequences in the Phanerozoic of the Canning Basin include:

- 1) The Ordovician to Middle Devonian megasequence is generally extensive in the southern Canning Basin but only locally preserved in the north.
- 2) The Middle Devonian to mid-Carboniferous megasequence is only present in the northern Canning Basin and varies significantly in thickness from the Jurgurra Terrace to the Lennard Shelf.
- 3) The unconformably overlying mid-Carboniferous to Triassic



Stratigraphy of the Canning Basin



Location of the seismic traverse

megasequence is laterally extensive across the basin and was truncated by the Late Triassic to Jurassic Fitzroy Transpression unconformity.

- 4) The Jurassic to Cretaceous megasequence has a relatively uniform thickness in the southern Canning Basin but pinches out in the Fitzroy Trough.

The Canning Coastal seismic profile shows key features of the tectonic elements of the basin and their structural and stratigraphic history. For example, the Willara Sub-basin and Broome Platform are interpreted to have been uplifted before deposition of the Grant Group, causing increased erosion of mid-Ordovician to mid-Devonian stratigraphy towards the northern margin of the Broome Platform in

the coastal area. The Jurgurra Terrace deepens northeast towards the Fenton Fault system and forms a transitional tectonic unit between the Broome Platform and the Fitzroy Trough.

Two interpretations are suggested for depth to basement in the Fitzroy Trough:

- The deep option is characterised by a strong acoustic response below a thick interval of no reflection.
- The shallow option correlates with offset seismic profiles and relatively shallow intersection of metasedimentary rocks.

Both interpretations imply a considerable amount of reverse movement along the Fenton Fault system and a complex history of fault movement.

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GSWA's innovative Digital Core Atlas

Leon Normore and Louisa Dent
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Geological Survey of Western Australia



Olympic 1 drilling

The Canning Basin Drilling Project is a collaboration between Geological Survey of Western Australia (GSWA), Geoscience Australia (GA) and petroleum exploration companies. The aim of the project is to sample and analyse newly cored sections in the Canning Basin for stratigraphic, petroleum systems and CO₂ sequestration studies. Three wells – Olympic 1, Theia 1 and Senagi 1 – have been incorporated into this project to date (Table 1). The use of slim-hole coring (HQ = 63 mm diameter) has resulted in three continuously cored sections (with excellent recovery) totalling 1383.18 m of core.

Table 1. Core retrieved in the Canning Basin Drilling Project wells

Well	Industry partner	Date drilled	Total core (m)
Olympic 1	Buru Energy	May–June 2015	319.20
Theia 1	Finder Exploration	August–September 2015	777.95
Senagi 1	Buru Energy	October–November 2015	286.03

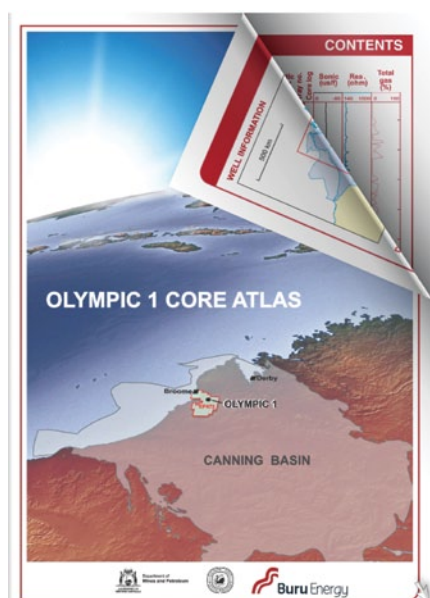


Figure 1. Cover page example

The Olympic 1 well, drilled on the Broome Platform, was the first well in this program and cored a continuous section from the base of the Willara Formation through nearly the entire Nambheet Formation. Prior to the drilling of this well, core from this Lower to Middle Ordovician section of the stratigraphy, particularly the Nambheet Formation, was limited.

The Olympic 1 cored section has nearly doubled the existing available core of the Nambheet Formation for the entire Canning Basin making it very valuable for stratigraphic and petroleum systems analysis. To help characterise this cored section a range of analyses were conducted, including biostratigraphy, geochronology, inorganic geochemistry, organic geochemistry, petrography and petrophysics.

The new GSWA Digital Core Atlas was designed during the Canning Basin Drilling Project to deal with the large volumes of data generated from the various types of core analyses being undertaken. The original concept was based on a paper core atlas on the Theia 1 petroleum well provided by Finder Exploration. This new product being developed by GSWA is designed to display detailed photographs of the cored section and all related data in an easily accessible format in one user-friendly location (Fig. 1). The analysis results are incorporated into an electronic book design with interactive links to the datasets using Flipbuilder software (Fig. 2).

The main pages of the atlas display core images on the



Figure 2. The Digital Core Atlas features an electronic book design

left and a well log and legend for datasets on the right (Fig. 3). The photos include both field photos of core taken immediately after retrieval from core barrels and its placement into trays, and a HyLogger photo taken at the GSWA Perth Core Library. Icons are placed on the field photos corresponding to the position of samples taken and analysis type (Fig. 4). Each icon is linked to the data recovered from that individual sample and the results can be accessed by a simple mouse click (Fig. 5). The location of the individual core tray is marked on the adjacent well log to provide the user with a clear understanding of which part of the stratigraphy they are viewing.

In addition to the main core images, an appendix and summary page listing all the samples and analysis results for each data set are included. These sample lists link to each individual sample results and also contain additional links to the raw data reports in the GSWA petroleum exploration database 'Western Australian Petroleum and Geothermal Information Management System' (WAPIMS), from where the data can be downloaded.

The first Digital Core Atlas for the Olympic 1 cored section is well advanced and is due to be released by GSWA in mid-2017.

Since its inception, the Atlas has evolved through numerous design phases to create a working template and streamlined process that, ideally, will be used to generate future Core Atlases for the Theia 1 and Senagi 1 cored sections. It has been recommended to GSWA that non-cored sections of holes also be included in future Atlases.

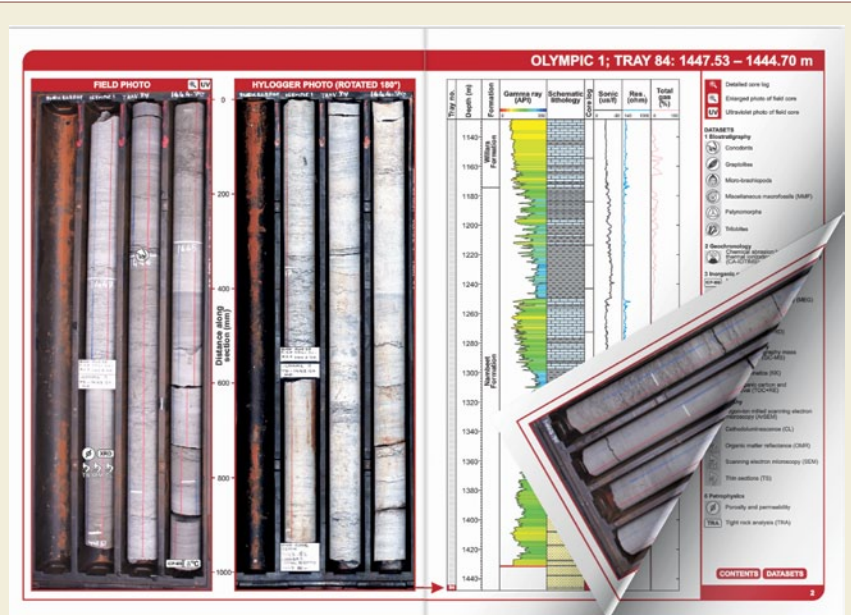


Figure 3. Example of core display pages

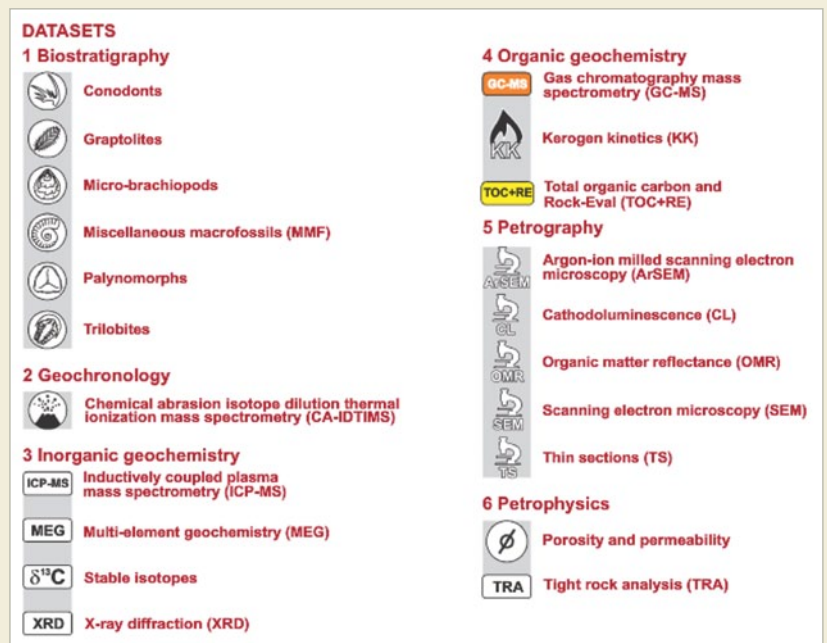


Figure 4. Examples of petrography dataset links in the Digital Core Atlas

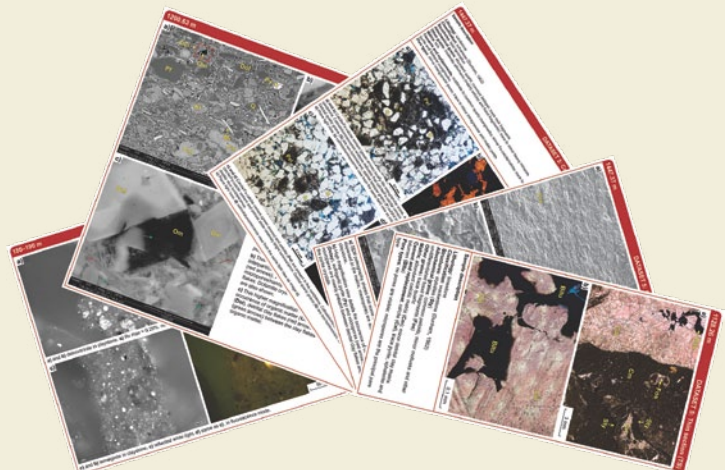


Figure 5. Examples of other data linked to the core sample

New Paleozoic book

Contributed by
Geological Survey of Western Australia

A Paleozoic perspective of Western Australia is the third of five volumes published by the Geological Survey of Western Australia under the banner of 'Western Australia unearthed', following *The birth of supercontinents and the Proterozoic assembly of Western Australia* and *Australia goes it alone – the emerging island continent 100 Ma to present*. These books are aimed at trainee and professional geologists, especially newcomers to Western Australia, to provide an introduction to the geology and economic potential of the diverse terrains that make up the State. Each book sets out GSWA's current ideas on the geological history of Western Australia.

Paleozoic strata are preserved across about 30% of onshore Western Australia in both the coastal and interior basins. These sedimentary successions are largely unmetamorphosed and little deformed by Phanerozoic orogenic events in comparison to the Precambrian. Igneous rocks are rare apart from the mid-Cambrian Kalkarindji Large Igneous Province in the east of the State and northern Australia.

Lower Ordovician limestone and shale outcrop, Prices Creek, northern Canning Basin



A Paleozoic perspective of Western Australia

by
Arthur J Mory



The Paleozoic depositional and structural history of the onshore basins is illustrated by a series of statewide paleogeographic reconstructions paired with isopach images – the time slices are based on regional correlations underpinned by biostratigraphic and paleontological studies and correspond to 2nd-order cycles. Four main phases of basin evolution are recognised: Cambrian intracratonic sag followed by three rift phases of Ordovician – Early Devonian, Middle Devonian – mid-Carboniferous and latest Carboniferous – Permian age. Most of the Paleozoic is characterised

by fluvial – shallow-marine facies with the deepest marine facies flanking now exhumed Devonian carbonate reefs in the northern Canning and Southern Bonaparte Basins probably at depths of up to several hundred metres. The Gondwanan glaciation reached its peak in the Late Carboniferous but its effect continued into the Early Permian when much of the State was covered by glacially derived sediment. At the end of the Paleozoic the loci of deposition shifted offshore to encompass the present North West Shelf apart from the Perth Basin.

A pdf of the volume can be downloaded free, or a soft-back copy ordered at a cost of \$33.00, from the Department's eBookshop <http://dmpbookshop.eruditetechnologies.com.au/product/a-paleozoic-perspective-of-western-australia.do>



Fluvioglacial deposits of Permian Grant Group disconformably overlain by deltaic facies of Poole Sandstone, Mount Hutton, Canning Basin

GSWA's historical Paleontology Reports now available online

Sarah K Martin

Senior Geologist

Geological Survey of Western Australia



Retitriteles watheroensis Backhouse, 1978 (bottom) and other spores and pollen, F6595, Watheroo Line 2 water bore, Perth Basin. The palynology of this well is described in Paleontology Report 1967/38.

The Geological Survey of Western Australia (GSWA) is the custodian of more than 100 years of paleontological data, including publications and physical collections. A key part of this legacy dataset is the GSWA Paleontology Reports, which represent nearly forty years of biostratigraphic research across Western Australia.

GSWA paleontologists began producing these reports in 1962, with each publication relating to an enquiry made by GSWA geologists or external clients. Paleontology Reports were produced until the year 2000, with a total of 1818 reports written during this period. Originally intended only for departmental use, the reports were never formally typeset, resulting in some inconsistencies in spelling and style. Despite this variability in presentation, the basic data contained in the reports remains a valuable resource for paleontological and biostratigraphic studies across the State, including onshore petroleum and mineral exploration studies. This is particularly true for exploration in areas such as the Perth Basin, where the age of successions is mostly constrained using palynology, and deep water and mineral boreholes provide much needed data points between widely spaced wells. Further value is added by the curation of most reported samples within the GSWA paleontology collection, allowing material to be reinterpreted if required.

The reports cover a wide range of geological ages, fossil groups, and geographic regions, and provide the basic data on which some of GSWA's key stratigraphic and biostratigraphic studies were built, including:

- Palynological studies on numerous government-drilled water bores, which formed the basis for Backhouse's (1978; 1988) Late Jurassic and Early Cretaceous palynological schema for the Perth Basin.
- Preliminary studies on stromatolites across the State, leading to concepts of Precambrian stromatolite biostratigraphy still used extensively by GSWA.
- Eon or Period reviews of all taxa described within Western Australia (at the time of compilation) covering the Precambrian to Quaternary, of which only the Permian volume (Skwarko, 1993) was formally published.

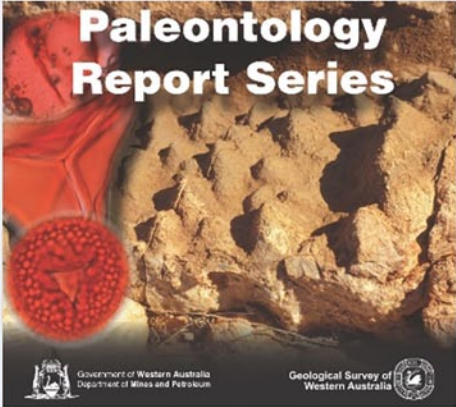
The Paleontology Reports were previously scanned and made available as a digital data-package in 1996; however, this product was not subsequently updated and many of the original scans were of poor quality. To improve the accessibility of this information, the legacy Paleontology Reports were recently rescanned at high resolution using optical character recognition, or were manually retyped

where the original report was difficult to read. The reports in PDF format are now available as free downloads through the DMP website, using the same digital publication platform used by GSWA to deliver Records, Reports, and other documents. The Paleontology Reports are provided with an independent search page, with terms tailored to the report contents – therefore, the reports are searchable by borehole name, fossil group, or GSWA field or Paleontology collection (F) sample numbers, as well as the more standard map sheet, tectonic unit, or geological age searches (Fig. 1). As of early 2017, the legacy reports are only accessible via this text-based search page, with plans for spatial searching using GeoVIEW.WA in the near future.

Along with the online release of legacy Paleontology Reports, a new series of Paleontology Reports is also being launched (Fig. 2). These new reports will be written on an ad hoc basis, and will be fully peer-reviewed and edited in line with other GSWA products. The reports are intended to present new discoveries or basic paleontological data, particularly those materials or sites unrelated to active GSWA projects. The first of these reports (Martin, 2016) is already available to view on the Paleontology Report search page. Report compilations, gathering all of the Paleontology Reports for the previous calendar year, will also be released yearly via eBookshop www.dmp.wa.gov.au/ebookshop-1508.aspx.

Search For Documents Select Cabinet: **Paleontology Reports**

Search



[Introduction to Paleontology Reports, 2016](#)

Title

Author

Year

Series number

Fossil type

Fossil group

F No.

GSWA no.

Locality Type

Well / bore name

Map Name

[Click for map index](#)

Geo Province

Geological age

Display results as Condensed Thumbnail Sorted

Number of results per page

Include archived documents

Search

▲ Figure 1. Online search page for GSWA Paleontology Reports

PR 2016/1.pdf GSWA Paleontology Report 2016/1

F52428: Early Cretaceous ammonite (Oppeliidae: Aconeceratinae), Muderong Shale, Barrow Island F45M core

<i>F number</i>	F52428	<i>UWI</i>	W001363	<i>Zone (GDA 94)</i>	50
<i>GSWA number</i>	222009	<i>Depth (m)</i>	7873	<i>Easting</i>	332167.75
<i>WAROX site number</i>	SKMPLR150001	<i>DLAT</i>	-20.839353	<i>Northing</i>	7694790.86
<i>Photo number</i>	IMG_5915	<i>DLONG</i>	115.387003		

Material and locality

F52428: Barrow Island F45M, core 1, 787.3 m (MGA Zone 50, 332167E 7694791N)

Muderong Shale (Valanginian–Aptian, ‘M2 zone’. This borehole was drilled in August 1984, by West Australian Petroleum Pty Ltd; see WAPET (1984) for more information on this drillhole.

Report

The sample consists of a well-preserved microconch ammonoid, preserved in lateral aspect on a brown-grey siltstone bedding surface (Fig. 1). There are no other obvious macrofossils preserved on the same core surface. To protect this ammonoid from degradation caused by core handling and jostling of core segments within storage trays, a short (~30 mm thick) section containing the fossil was extracted and registered within the GSWA Paleontology collection, under the number F52428.


Systematic paleontology

SUBORDER Ammonitina Hyatt, 1889
 SUPERFAMILY Haplocerataceae Zittel, 1884
 FAMILY Oppeliidae Douvillé, 1890
 SUBFAMILY Aconeceratinae Spath, 1923
 GENUS *Aconeceras* Hyatt, 1902
 SUBGENUS *Sanmartinoceras* Bonarelli in Bonarelli and Nágera, 1921
Aconeceras (*Sanmartinoceras*) sp.


Description

Sample preserves umbilicus, phragmocone and body chamber (Fig. 1a). Calcareous material of shell preserved, although fractured in places; where shell is missing, siltstone matrix is observed filling chambers.

Shell small (Table 1), involute, with outermost whorl overlapping underlying whorl by about 40%. Due to the nature of preservation, whorl width cannot be measured or estimated, and siphuncle cannot be observed; however, based on broken segments, including in the body chamber, it is suggested that whorls have an oxycone or compressed profile, likely narrowing to a bladed or acute apex.



1 cm



5 mm

Figure 1. *Aconeceras* (*Sanmartinoceras*) sp. (Oppeliidae: Aconeceratinae), Muderong Shale, Barrow Island F45M (F52428): A. fossil overview; B. close-up of whorl flank, showing suture.

1

▲ Figure 2. The new series of GSWA Paleontology Reports

A summary of the Paleontology Reports:

- The most prolific Paleontology Reports author is palynologist John Backhouse, with a total of 1004 reports. The next most prolific report writer is fellow palynologist Barry Ingram, with 250 reports.
- The greatest number of reports written in a single year was in 1975 with 150 reports finalised. Numbers of reports released per year decreased in the 1980s and 1990s, with the last two legacy reports released in 2000. Only a single Paleontology Report (current series) was written in 2016.
- Spores and pollen are the most commonly reported fossils in the Paleontology Reports, being mentioned in 1302 reports, followed by microplankton, which are mentioned in 766 reports. Outside of palynomorphs, foraminifera (162 reports) are the most commonly recorded fossil group, with bivalves the most commonly cited macroinvertebrates (110 reports). A total of 151 reports relate to palynology samples lacking any fossils (i.e. barren samples).
- Reports cover from the Paleoproterozoic to the Recent, with the Cretaceous the most commonly recorded geological period (913 reports), followed by the Jurassic (332 reports). Precambrian fossils are mentioned in 80 reports.
- Sites in the Perth Basin feature in 1233 reports, with far fewer reports on the Canning (108 reports), Southern Carnarvon (100 reports), and Northern Carnarvon Basins (37 reports). There are 25 statewide reports, mostly Eon and Period reviews. Numerous Proterozoic and Archean basins are also covered in the Paleontology Reports, although in fewer reports than the Phanerozoic basins.
- Water bore samples dominate material in the Paleontology Reports, being mentioned in 1237 reports. This is followed by outcrop samples (315 reports), mineral boreholes (154 reports), and petroleum wells (75 reports).

Access to the Paleontology Reports search page, and general information on paleontological and biostratigraphic studies at GSWA, is available at www.dmp.wa.gov.au/Geological-Survey/Paleontology-20599.aspx.

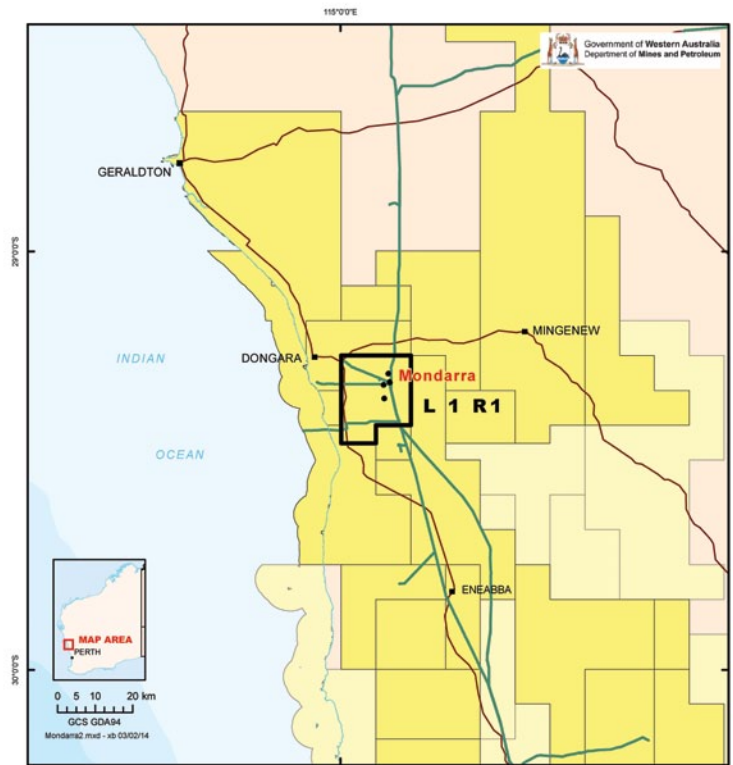
Please send any questions or comments to paleontology@dmp.wa.gov.au.

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An overview of underground gas storage in Western Australia

Majed Al Naser
Senior Reservoir Engineer
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Location map of the Mondarra gas storage facility near Dongara

Introduction

Natural gas is consumed at different rates throughout the year and, in fact, consumption can be quite volatile. There are several factors that contribute to the volatility of natural gas supply and demand, including weather conditions, emergency shutdown of gas production facilities, requirements to manage extra produced gas volumes from peak production when demand is low, and instability in gas export markets.

Gas producers and distributors adopt different strategies to ensure the reliability of domestic energy supplies during periods of peak demand. Such strategies may include storing gas in pipelines, special vessels or tanks (liquefied natural gas), as well as in underground geological formations, otherwise known as underground gas storage (UGS).

UGS can play a critical role in maintaining a balance between supply and demand. The process involves injecting natural gas into depleted oil or gas reservoirs, or alternatively, injecting into suitable geological formations, such as salt caverns or aquifers. Injection of pressurised gas into a rock formation increases the formation pressure. The formation therefore acts as a pressurised storage container. Gas is usually injected when supply exceeds demand. When gas demand

exceeds supply, the gas is recovered from the underground storage formation to meet requirements.

UGS in WA

There are presently two UGS projects in Western Australia (WA). The Mondarra UGS facility, which commenced operations in 1994, is located near Dongara and the Parmelia and Dampier to Bunbury Natural Gas pipelines and is operated by the APA Group. The second UGS project is the Tubridgi facility, operated by DDG Tubridgi Pty Ltd, which is located about 30 km from Onslow in the State's North West.

The Mondarra gasfield was discovered in 1968 and commenced production in 1972. In 1994, after the field was depleted, it was converted into a UGS facility. APA Group acquired the Mondarra facility in 2004 and committed to expanding the facility's storage capacity to 15 PJ. Today, the facility has the capacity to deliver gas at 150 TJ/d and inject at 70 TJ/d. The Mondarra UGS project is considered to have a strategic value for the WA gas market. Mondarra played a significant role in supplying natural gas to the State during the Varanus Island incident and the North West Shelf Group Dampier Domgas outage, in 2008.

Tubridgi UGS is in the initial stage of development, with the first wells for UGS being drilled. Tubridgi is another

depleted gasfield, originally discovered in 1981 with production commencing in 1991. In 2006, the field was shut in and the production wells were decommissioned in 2011. The Tubridgi UGS project is strategically located in close proximity to the Wheatstone and Macedon domestic gas production facilities.

DMP's role in regulating UGS

As a regulatory body, Department of Mines and Petroleum (DMP) realises that UGS can play a critical part in the gas delivery system and energy security for Western Australia, and is constantly working on improving its processes. DMP is aware of past challenges and failures in relation to UGS, such as leakage incidents that have occurred elsewhere (for example, the Yaggy incident in Kansas and the Aliso Canyon incident in California).

Since Mondarra is an operational project, APA and DMP have worked to ensure that risks associated with UGS operations are monitored and managed to leading industry standards. Regulations cover this type of petroleum operation as well as more conventional production activities. DMP has developed criteria for assessment and procedures to reduce potential risks associated with UGS operations in order to improve safety, environmental and good oilfield

practice. The process for approving a potential UGS project in WA takes into consideration a number of factors to ensure effective risk management. Three main areas which DMP focuses on are:

- Reservoir management: including the development of a coherent field management plan which demonstrates a good understanding of risks to subsurface formation integrity and related reservoir management uncertainties. Ultimately, DMP requires that the proposed field management plan should ensure responsible resource management.
- Well integrity management: including rigorous planning, risk assessment, management and mitigation to ensure well integrity.
- Safety and environmental management: demonstrated in the safety case and environment plans that identified risks are managed to as low as reasonably practicable (ALARP).

In addition, DMP has recently adopted a proactive UGS monitoring system to trigger early concerns about

possible risks related to reservoir and well integrity. This approach is based on dynamic data analysis of parameters such as pressure, injection and production data. DMP regularly engages with UGS operators to address any concerns resulting from this monitoring process.

Benefits of UGS

UGS can play a critical role in providing strategic, technical and economic advantages to the gas market. On occasion, UGS has proven its strategic effectiveness in supplying gas during emergency shutdown incidents or crises. The use of UGS can maintain an efficient supply of gas during peak demand periods. It has the capacity to accommodate surplus volumes of gas produced during low demand periods and make this volume available when demand is high. This ability stabilises gas production by avoiding any unnecessary curtailment to production, thus ensuring a steady gas supply to the domestic market and managing the volatility of gas prices.

Another benefit that UGS provides is greater flexibility to the industry in the gas delivery system. The ability to store excess gas underground means

that additional processing facilities do not need to be constructed with the capacity to store excess gas, therefore capital investment is reduced. This, in turn, stabilises the price of gas.

Future of UGS in Western Australia

The increasing demand by the WA domestic gas market underscores the need to ensure a stable gas supply.

Global adaptation of strict environmental legislation and regulation to use gas as an environmentally attractive fuel will significantly increase the future demand for gas. UGS can play a vital role in the energy mix as we move towards a lower carbon economy and renewable targets.

Extended periods of low crude oil and gas prices tend to depress oil and gas exploration activities. This may also affect new projects coming online or delay any significant increment to the proven gas reserves, in turn, affecting supply and demand in the gas market. Expanding UGS operations can contribute to balancing such possible changes to the gas market.



Aerial view of the Mondarra gas storage facility

Photo © APA Group

Tubridgi Gas Storage Agreement approved by Minister

Stephen Collyer
Manager Petroleum Register
Petroleum Division



An aerial view of the new Tubridgi gas storage facility

On 23 January 2017, the then Minister for Mines and Petroleum Hon Sean L'Estrange MLA and DDG Tubridgi Pty Limited (DDGT) entered into an Agreement under Section 67 of the *Petroleum and Geothermal Energy Resources Act 1967* giving approval for the injection, storage and recovery of petroleum for the Tubridgi Gas Storage Project (the Project).

The Project will play an important role in enhancing energy security in Western Australia and will provide opportunities to gas producers and customers, who require storage capacity to bank unused gas, smooth production profiles or to store gas to cover planned production outages. When fully operational, the facility could supply 5% of Western Australia's domestic gas needs for up to 20 days.

The Project will utilise the depleted Tubridgi gasfield, which lies within DDGT's wholly owned Petroleum Production Licence L 9, approximately 30 km from Onslow in the State's North West. The Tubridgi gasfield produced 69 PJ of dry gas between 1991 and 2004.

Once operational, in June 2017, the Project will be the largest gas storage facility in Western Australia. The construction of the plant and the drilling and testing of the injection/recovery wells is currently underway.

The estimated total project cost is approximately \$69 million. The Project has storage capacity of approximately 42 PJ and planned injection and recovery rates of around 50 TJ/d.

From a technical perspective, the Project has the advantage of having a relatively shallow reservoir (approximately 550 m), with resulting low injection pressures. Geotechnical studies have shown that the reservoir has excellent permeability and pressure support through an active aquifer, which should ensure good deliverability of gas.

The Project is strategically located in close proximity to the Chevron-operated Wheatstone and BHPB-operated Macedon domestic gas production facilities and is connected to the Dampier to Bunbury Natural Gas Pipeline by existing pipelines. CITIC Pacific Mining operator of the Sino Iron magnetite project at Cape Preston will be the foundation customer under a 10 year agreement with options for a further five years. DDGT is also negotiating additional contracts with other potential customers.

From a regulatory (or governance) point of view, the Agreement provides for the effective regulation of all activities associated with the Project through approved safety, environment, well management and

field management plans. Additionally, if during the recovery of pipeline gas indigenous gas is produced as a result of this activity the Agreement covers the payment of royalties; otherwise, royalty payments are the responsibility of the initial gas producer.

The terms of the Agreement were successfully negotiated with DDGT over approximately a six week period from mid-December 2016 to mid-January 2017 by senior officers from the department's Petroleum Division and Legal Services Branch with the assistance of the State Solicitor's Office.

The collaborative and open discussions that took place between industry and government, which led to the signing of this important agreement in such a short time frame, should be taken as an example of the ability of government and industry to work together both for the benefit of the State and the industry.

The work program for the firm two year period includes a magnetotelluric survey and geological and geophysical studies, with an estimated expenditure of \$600,000. The secondary period includes a 2D seismic survey, an exploration well and further studies, with an estimated expenditure of \$6,000,000.

EP 458

The first renewal of petroleum exploration permit EP 458 was granted to Buru Fitzroy Pty Ltd, Diamond Resources (Fitzroy) Pty Ltd and Rey Oil and Gas Pty Ltd for a further five years, effective 6 January 2017. The renewed permit comprises 36 graticular blocks within the Canning Basin over a 2920.50 km² area in Western Australia's far northwest.

The work program for the firm two year period includes a magnetotelluric survey and geological and geophysical studies, with an estimated expenditure of \$600,000. The secondary period includes a 2D seismic survey, an exploration well and further studies, with an estimated expenditure of \$6,000,000.

Petroleum Retention Lease (Renewal)

R 1

On 11 October 2016, the second renewal of petroleum retention lease R 1 was granted to Gulliver Productions Pty Ltd and Indigo Oil Pty

Ltd for a period of five years. R 1 comprises three graticular blocks within the Canning Basin over a 245.15 km² area on the Point Torment Peninsula in Western Australia's far North West.

The Point Torment gasfield location was originally declared in 1998 and this was followed by the initial grant of the R 1 retention lease in 2003.

The five year work program includes airborne and geochemistry surveys, geological and geophysical mapping, reprocessing of existing seismic data and modelling to evaluate the potential of the reservoir.

Pipeline Licence

PL 112

On 25 August 2016, licence PL 112 was granted for the Wheatstone Ashburton West Pipeline Deviated Section for an indefinite period. The 230 m pipeline connects the two sections of PL 103, the Wheatstone Ashburton West Pipeline, near Onslow in the northwest of Western Australia.

The registered holder of PL 112 and PL 103 is DBP Development Group Nominees Pty Limited, with DBP Development Group Pty Limited the approved pipeline operator.

Commonwealth Joint Authority Awards

Petroleum Exploration Permit

WA-524-P

Petroleum exploration permit WA-524-P within the Northern Carnarvon Basin of Western Australia was granted to Carnarvon Petroleum Ltd, effective 9 September 2016, over release area W15-8.

WA-525-P

Petroleum exploration permit WA-525-P within the Northern Carnarvon Basin of Western Australia was granted to BP Developments Australia Pty Ltd, effective 3 November 2016, over release area W15-14.

WA-526-P

Petroleum exploration permit WA-526-P within the Northern Carnarvon Basin of Western Australia was granted to Chevron Australia New Ventures Pty Ltd, effective 20 February 2017, over release area W16-7.

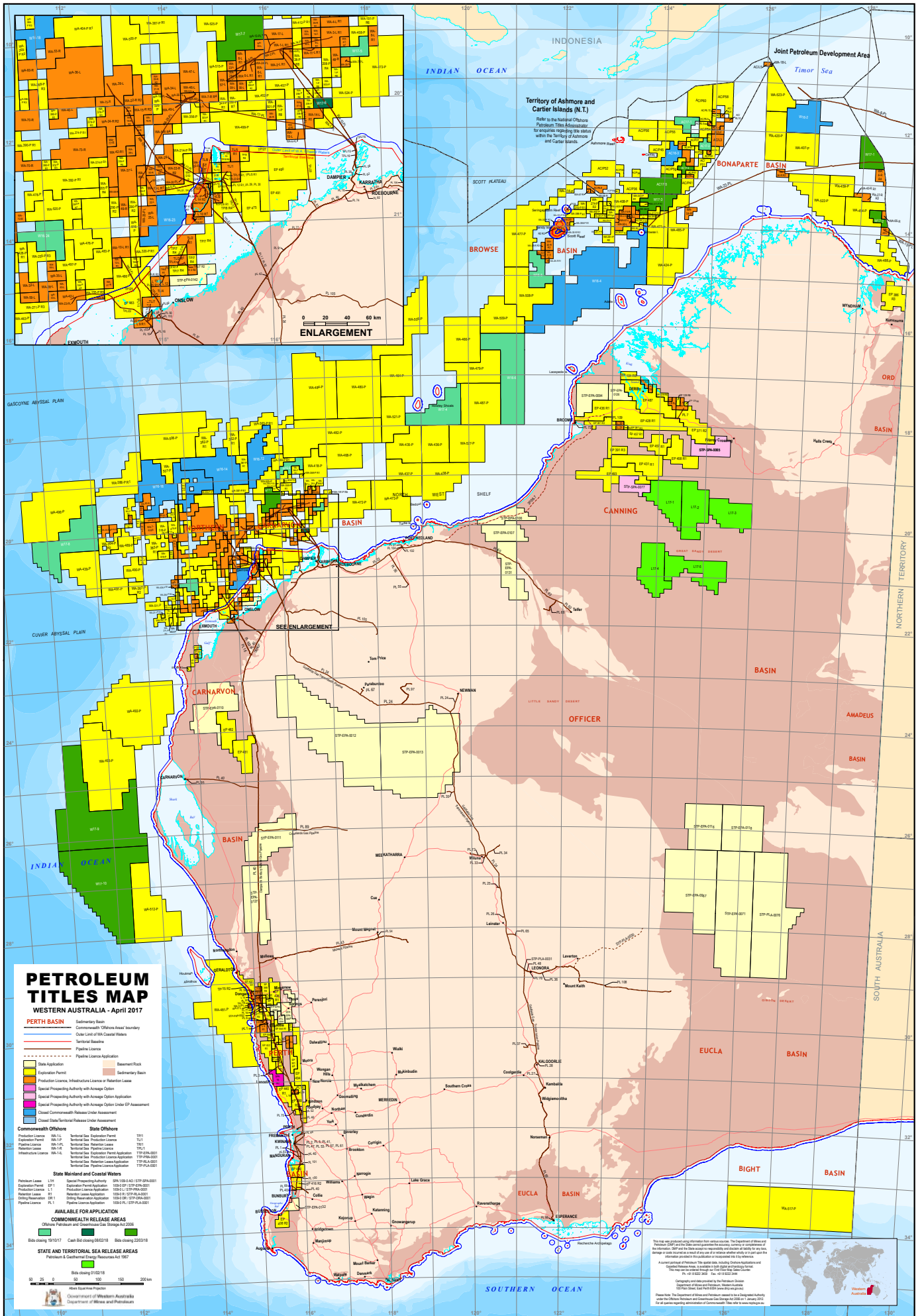
Petroleum Exploration Permit (Renewal)

WA-367-P

The renewal of petroleum exploration permit WA-367-P within the Carnarvon Basin of Western Australia was granted to Chevron Australia (WA-367-P) Pty Ltd and Shell Australia Pty Ltd, effective 3 November 2016.



Buried pipeline easement in the Pilbara area



WA-398-P

The renewal of petroleum exploration permit WA-367-P within the Browse Basin of Western Australia was granted to ConocoPhillips (Browse Basin) Pty Ltd, Origin Energy Browse Pty Ltd and PetroChina Investment (Australia) Pty Ltd, effective 19 January 2017.

WA-315-P

The renewal of petroleum exploration permit WA-315-P within the Browse Basin of Western Australia was granted to ConocoPhillips (Browse Basin) Pty Ltd, Origin Energy Browse Pty Ltd and PetroChina Investment (Australia) Pty Ltd on 18 January 2017.

WA-364-P

The renewal of petroleum exploration permit WA-364-P within the Carnarvon Basin of Western Australia was granted to Chevron Australia (WA-364-P) Pty Ltd and Shell Australia Pty Ltd, effective 3 November 2016.

WA-409-P

The renewal of petroleum exploration permit WA-409-P within the Carnarvon Basin of Western Australia was granted to Cue Exploration Pty Ltd, effective 13 October 2016.

Petroleum Retention Lease**WA-74-R**

Petroleum retention lease WA-74-R was granted to Santos Browse Pty Ltd, Chevron Australia (WA-274-P) Pty Ltd and INPEX Browse E&P Pty Ltd over the Ichthys North/Concerto Extension Location, effective 17 November 2016.

WA-75-R

Petroleum retention lease WA-75-R was granted to Chevron Australia (WA-374-P) Pty Ltd, Shell Australia Pty Ltd and Mobil Australia Resources Company Pty Limited over the Eurytion Extension Location, effective 7 December 2016.

WA-76-R

Petroleum retention lease WA-76-R was granted to Chevron Australia (WA-444-P) Pty Ltd, Shell Australia Pty Ltd and Mobil Australia Resources Company Pty Limited over the Chrysaor Extension Location, effective 7 December 2016.

Petroleum Retention Lease (Renewal)**WA-40-R**

The renewal of petroleum retention lease WA-40-R was granted to ENGIE Bonaparte Pty Ltd, Santos Limited and Bonaparte Gas and Oil Pty Ltd, effective 2 November 2016.

WA-42-R

The renewal of petroleum retention lease WA-42-R was granted to Chevron Australia Pty Ltd and Chevron (TAPL) Pty Ltd, effective 22 December 2016.

WA-43-R

The renewal of petroleum retention lease WA-43-R was granted to Quadrant Northwest Pty Ltd, effective 3 November 2016.

WA-6-R

The renewal of petroleum retention lease WA-6-R was granted to ENGIE Bonaparte Pty Ltd, Origin Energy Bonaparte Pty Ltd, Santos Limited and Bonaparte Gas and Oil Pty Ltd, effective 23 November 2016.

WA-7-R

The renewal of petroleum retention lease WA-7-R was granted to BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Pty Ltd, Chevron Australia Pty Ltd, CNOOC NWS Private Limited, Japan Australia LNG (MIMI) Pty Ltd, Woodside Energy Ltd and Shell Australia Pty Ltd, effective 24 January 2017.

WA-15-R

The renewal of petroleum retention lease WA-15-R was granted to Chevron (TAPL) Pty Ltd, Chevron Australia Pty Ltd, Mobil Australia Resources Company Pty Limited, Osaka Gas Gorgon Pty Ltd, Shell Australia Pty Ltd and JERA Gorgon Pty Ltd, effective 28 December 2016.

Pipeline Licence**WA-27-PL**

Pipeline licence WA-27-PL was granted to Woodside Energy Ltd, BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Pty Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI)

Pty Ltd and Shell Australia Pty Ltd for the GWF-2 pipeline, effective 6 October 2016. The 35.4 km pipeline connects the Lady Nora/ Pemberton and Goodwyn Alpha Pipeline End Termination Systems. Woodside Energy Ltd is the approved pipeline operator.

Petroleum Production Licence (Renewal)**WA-13-L**

The renewal of petroleum production licence WA-13-L was granted to Quadrant Oil Australia Pty Limited, Santos (BOL) Pty Ltd, Quadrant East Spar Pty Ltd and Quadrant Kersail Pty Ltd, effective 19 February 2017.

WA-14-L

The renewal of petroleum production licence WA-14-PL was granted to Vermilion Oil & Gas Australia Pty Ltd, effective 20 March 2017.

DMP community engagement in the Kimberley

Jason Medd
Principal Policy Officer
Petroleum Division



The Kimberley region in the State's far North West hosts one of Australia's largest and least explored petroleum provinces, the Canning Basin. One of Western Australia's first petroleum wells, Mt Wynne 1, was constructed in the Canning Basin and completed in 1922. There has been continued interest from petroleum exploration companies, with mixed results, since this time.

Due to ongoing petroleum industry interest and activity in the Kimberley, the Department of Mines and Petroleum (DMP) considers this area to be a priority for stakeholder engagement and relationship building. Between 7 and 11 November 2016, a small group of DMP officials led by the Executive Director of Petroleum, Jeff Haworth and including Marnie Leybourne – Director of Operations,

Environment Division, Jason Medd – Principal Policy Officer, Petroleum Division and Brian Lloyd – Kimberley Liaison Officer, covered over 1100 km in five days with 12 separate engagements.

A wide range of stakeholders were involved, including Local Government, Native Title representatives, pastoralists,



Jason Medd, Jeff Haworth and Marnie Leybourne at the Fitzroy River Bridge



DMP officers Brian Lloyd, Jason Medd, Jeff Haworth and Marnie Leybourne at the Ord River Scheme

aboriginal groups and local business representatives. The group also visited emerging horticultural projects near Derby and the Ord River Scheme.

The most common issue that was raised in nearly all of the discussions was related to water, principally water resource protection and accessibility. It was demonstrated time and again the importance of water to many of the existing and emerging industries in the region and its importance to communities.

The decline in the resources industry in the Kimberley was identified by a number of key stakeholders as an issue of concern, particularly with the recent closure of a number of mines and the cessation of oil production at the Ungani oilfield. However, there was much interest in emerging resource projects, including ongoing petroleum exploration in the

Kimberley, the Thunderbird Mineral Sands Project between Derby and Broome and the Browns Ranges Rare Earths prospect east of Halls Creek. There was also keen interest in looking at ways in which different activities could be combined for mutual benefit and additional employment opportunities.

DMP received constructive feedback from Local Government, particularly around petroleum acreage management and information sharing. One of the key learnings for DMP from Local Government in the Kimberley was the significant importance of the resources industry to Local Government finances and the sensitivity to Local Government of any significant changes to mineral and petroleum operations and title areas. This feedback has triggered several reforms with regard to how DMP engages with stakeholders,

specifically around nomination of areas for acreage release for competitive bidding and providing timely information of any changes in resource related activities.

DMP will continue to keep communities in the Kimberley informed on petroleum exploration and production matters and provide fair and impartial information to stakeholders.

Expansion of the Perth Core Library

Joshua Williams
Policy Officer
Petroleum Division



HyLogger and core trays

On 2 November 2016, the then Minister for Mines and Petroleum, Sean L'Estrange MLA, officially opened the \$7.3 million expansion to the Perth Core Library at Carlisle.

The Perth Core Library was initially constructed at Carlisle in 2002 to house petroleum and mineral core. These geological samples were either submitted by petroleum companies to comply with permit requirements, or donated by resource companies to expand the geological knowledge in areas of the State where exposure was limited. Petroleum core and cuttings can be used to interpret depositional environment of sedimentary rocks, analyse their physical properties and to assess the evolution of petroleum systems (source rocks, fluid movement and

entrapment). The State Government has been storing petroleum core and cuttings since the first onshore petroleum well was drilled at Rough Range in 1953, with Rough Range 1 material currently available for viewing at the Perth Core Library.

The Perth Core Library was initially built with a capacity of 8500 pallets, or 400 km, of core, and included nine racks indoors for the viewing of petroleum core and a large outside viewing area for mineral core. From 2002 to 2005, material was received at an average rate of 200 pallets per year, increasing to close to 500 pallets per year during the boom years. This was partly due to the receipt of offshore petroleum core managed by the National Offshore Petroleum Titles Authority (NOPTA).

As part of the expansion project, the Perth Core Library now has space to store 15,300 core pallets; new viewing areas have also been added, with an extra ten racks of viewing space to cope with the 300% increase in core viewings from 2010 to 2014. During 2014–15, a record of approximately 100 km of core was laid out for inspection, with the number of samples taken (petroleum and minerals combined) averaging around 5000 per year. The aim is to reduce core-viewing wait times, which before the expansion ranged from six weeks' wait for companies wishing to access a small amount of core, to up to six months for a large amount of core.

The indefinite retention of core and cuttings allows rapid and cost effective reassessment. Storing core and cuttings in the Perth Core Library is highly cost effective compared to redrilling holes, especially offshore wells where the cost is in tens of millions of dollars per well.

Western Australia has historically managed the core and cuttings from offshore petroleum exploration in Commonwealth-controlled waters adjacent to Western Australia. However, after the formation of NOPTA in January 2012, the State entered into formal service-level agreements with NOPTA and Geoscience Australia to manage the core and cuttings from offshore petroleum exploration in other



Construction of the Perth Core Library expansion



Pallet racking at the Perth Core Library

Australian states and territories, the Ashmore and Cartier Islands, and Joint Petroleum Development Area. As a result, the Perth Core Library is now the western hub of the National Offshore Petroleum Data and Core Repository (NOPDCR), holding approximately two-thirds of NOPTA-managed cores and all cuttings, with the remaining one-third core held as back-up by Geoscience Australia, Canberra, as the NOPDCR eastern hub.

Under the *Petroleum and Geothermal Energy Resources Act 1967*, petroleum permit holders are required to submit the core and cuttings to the State government. This legislation is recognition of the strategic and long-term value of these physical assets. The well samples become available to the industry for further research once the confidentiality period has expired.

DMP closely monitors all samples taken and ensures that reports containing the data and interpretation are submitted to government. All of this ensures that future exploration is conducted efficiently and with less exploration risk.

Included in the new Perth Core Library expansion is a permanent home for the HyLogger spectral scanner, a suite of core- and chip-logging, and spectroscopic-imaging systems developed by the CSIRO Minerals Down Under Flagship. HyLogger systems were deployed to Australian State and Territory Geological Surveys in mid-2009 as part of the collaborative AuScope National Virtual Core Library (NVCL) program, and provide drill-core mineralogical and image data in a standard format. The current

generation of instruments (HyLogger-3) includes a thermal-infrared (TIR) sensor covering the wavelength spectrum in the range of 6000–14,500 nanometres (nm); this complements the previous visible near-infrared (VNIR, 380–1000 nm) and shortwave-infrared (SWIR, 1000–2500 nm) wavelength sensors. Thus, the HyLogger is capable of detecting a broad suite of anhydrous rock-forming minerals (feldspar, quartz, pyroxene, garnet, olivine, carbonate, and phosphate), and a number of hydroxyl-bearing minerals. HyLogger data provides objective information on the host-rock mineralogy and texture, as well as characterisation of lithological facies variation.

Since the installation of the NVCL HyLogger in the Perth Core Library in 2009, GSWA has scanned almost 26 km of core from 77 petroleum wells across the State, including wells from the Canning, Northern Carnarvon, Southern Carnarvon, Perth, Bonaparte and Officer Basins.

The Perth Core Library and the HyLogger provide vital geoscience information that promotes the mineral and energy productivity of the State and Commonwealth and encourages innovative research and more targeted, lower-cost exploration. More information on the Perth Core Library and how to access core or cuttings can be found on the Department of Mines and Petroleum website.



Core viewing facility at the Perth Core Library

Departmental integration under AS/NZS ISO 9001



Hayden Samuels

Compliance Monitoring Officer
Petroleum Division

As part of the Department of Mines and Petroleum (DMP) initiative to integrate more of its processes and IT systems across the department, the Environment Division (ED), Petroleum Division (PD) and Royalties Branch (RB) have combined their Quality Management Systems and have successfully achieved AS/NZS ISO 9001 re-certification after being audited in February 2017.

Under Quality Management standard AS/NZS ISO 9001 ED, PD and RB are certified to:

- provide leadership and excellence in the delivery of regulatory services and policy advice to improve environmental outcomes for mining, petroleum and geothermal exploration and development
- provide a regulatory environment that enables the responsible development of petroleum and geothermal energy resources of Western Australia
- committed to achieving quality within all the organisations area of responsibility associated with administering petroleum and mineral royalty legislation.

The AS/NZS ISO 9001 Certificate of Registration confirms that the Divisions/Branch management systems comply with the requirements

of the standard for provision of regulatory services for the minerals and petroleum industries, the community and policy advice to the Minister for Mines and Petroleum.

The Divisions/Branch have adopted Quality Assurance (QA), a customer focused strategy, to enhance the effectiveness of all its activities – maximising reliability and performance. The strategy, with continuous improvement, system documentation and regular internal audits, aims to meet specifications of the International Quality Management standard ISO 9001 across all Divisions/Branch activities.

The Executive Directors ED and PD and the General Manger RB are committed to comply with requirements and to continually improve the effectiveness in the Quality Policy.

Jeff Haworth, Executive Director Petroleum Division said, “Working across the Petroleum, Environment and Royalties areas to produce leading regulatory practices for petroleum has reinforced DMP’s reputation as a leading regulator. Independent auditing of our processes also can provide assurances to the Western Australian community that our regulatory framework is robust and continually scrutinised.”

The policy is reviewed on an annual basis.

Effective QA helps promote credibility about the integrity of ED, PD and RB management processes, and gives the Divisions/Branch a stronger customer focus – to which it is already committed. As a pre-condition, QA requires a Quality Policy, Business Online systems, Records and Forms/ Templates of all ED, PD and RB related processes and training to meet the specified requirements of the customer and quality objectives at a consistent level.

The Executive Directors ED and PD and the General Manger RB are the executives responsible for ensuring that the QA and Divisions/Branch policies are implemented, understood and maintained at all levels in the Divisions/Branch, namely:

- development and implementation of the Quality Management System (QMS) to ensure compliance with AS/NZS ISO 9001
- overseeing the performance and ongoing maintenance of the QMS
- reviewing the organisational relationships as they affect quality and developing proposals for improvement
- monitoring the QMS by auditing to determine compliance with the

requirements of AS/NZS ISO 9001 and reporting the performance to Senior Management

- resolving all matters associated with quality in the Divisions/Branch
- identifying ways and means of improving the QMS and proposing changes to management
- liaising with the customer to ensure that actual or potential quality problems are resolved.

Dr Phil Gorey, Executive Director Environment, said integrating the Quality Management processes with the Petroleum Division and the Royalties Branch is an excellent initiative and can only help Environment to continually improve the services that it provides to its customers.

Surveillance of the Divisions/Branch's System Certification is conducted by independent auditors qualified in inspecting, verifying and testing to ensure the Divisions/Branch's systems and services are compliant with regulations and standards. This certification is reviewed annually against Australian Standards, in the context of the QA manual. All QA findings, suggestions and complaints are followed through.

The Divisions/Branch are committed to achieve certification under the new AS/NZS ISO 9001:2015 standard by February 2018. The new ISO 9001:2015 standard strives to give additional momentum to the continuous and systematic improvement of processes within the Divisions/Branch.

David Norris, General Manager Royalties Branch stated that the QMS is established, documented and maintained, with the specific objective of ensuring that all work performed by the Royalties Branch meets the specified requirements of the quality objectives at a consistent level. "The structure is based on the principles of the AS/NZS ISO 9001 standard and the Branch is well placed to meet the requirements of the new AS/NZS ISO 9001:2015 standard by February 2018," he said.

Suggestions are welcome and form part of the QA process to help us to improve our service. You can make feedback/suggestions via the Department's Feedback and complaints system at www.dmp.wa.gov.au/Utilities/Feedback-and-complaints-8369.aspx.



Petroleum and Environment Executive Directors and Royalties General Manager signing the joint QMS policy and manual
Back left to right: Hayden Samuels, David Bowie and Enzo Sisti
Front left to right: Jeff Haworth, Phil Gorey and David Norris

Well integrity in Western Australia

Stuart Webster and Sandip Patel
Compliance Team
Petroleum Division



Conducting a well integrity test

The 2013 Australian Council of Learned Academies (ACOLA) report “Engineering Energy: Unconventional Gas Production, A study of shale gas in Australia” recommended that to better understand well integrity in the Australian context, studies should be conducted on the subject. The first report on this subject was published in the April 2015 Petroleum in Western Australia magazine (PWA). The Department of Mines and Petroleum (DMP) continues to monitor and review well integrity in Western Australia (WA). This article provides an update.

Background

From the start, a petroleum well is designed with well integrity in mind. When constructing a well, the highest risk is from pressures in subsurface formations. Fluids, such as oil, gas and water present in subsurface formations are under pressure from the overburden of rock above them. When a well is being drilled, this formation pressure is exerted on the borehole, potentially resulting in the flow of these fluids into the well. To counteract this pressure, the well is constructed using equipment that includes casing, wellhead, liners, cement, tubing, valves and packers. This equipment provides integrity by forming a series of barriers that control downhole pressures. At the same time, fluids and materials are

prevented from entering or exiting the well in an uncontrolled manner, thus maintaining environmental control.

The overriding principle in maintaining well integrity is that there must be at least two barriers, one primary and one secondary, in place, to prevent any potential leak path. Together, these barriers ensure the integrity of the well and their effectiveness is verified by pressure tests.

A barrier failure means that a well integrity issue exists but **does not** necessarily mean that the well integrity has been breached. Secondary barriers become active if a primary barrier fails, thus safeguarding the integrity of the well.

Well integrity must be maintained during the drilling of a petroleum well, and during the well’s production life that may span decades. Some of the factors that need to be considered to assure that well integrity is attained and maintained include: the geology of the area, the purpose of the well, subsurface pressure and temperature conditions, and location of potable water aquifers.

In WA, the construction and maintenance of a petroleum well must meet international standards in materials, methods and monitoring. Verification of these standards is carried out by regular pressure testing

of the well and its components. This continuous verification ensures that the integrity of the well is maintained over its life. While the well is being drilled, the drilling fluid and blow out preventers (BOPs) are additional barriers. Regular tests verify that these barriers are effective.

Compliance before drilling

To ensure compliance with the Petroleum and Geothermal Energy Resources (Resource Management and Administration) Regulations 2015 and Petroleum (Submerged Lands) (Resource Management and Administration) Regulations 2015 (the Regulations), DMP rigorously evaluates all applications for petroleum and geothermal wells in WA.

The Regulations are primarily objective based. It is up to the registered title holders to put risk management procedures in place that assess and rate risk and mitigate any failures. The principle of ‘As Low As Reasonably Practicable’ (ALARP) applies but it should be noted that if a risk is still unacceptable after being reduced to ALARP, it should not be undertaken.

Before approval is given to drill a well, a well management plan (WMP) is submitted by the registered holder and assessed by DMP. The WMP contains details on how the well will be constructed, what barriers are included in the well design and how

the barriers will be monitored. There are safety factors built into the design to ensure that the casing specification rating is more than sufficient to handle the worst case scenario presented by formation pressures. The WMP also states how the well will be controlled should an unexpected event occur. Having the ability to control the well is essential to ensure that the integrity of the well is maintained.

Once drilling has been completed, a revision of the WMP must be approved before any further activity can occur on the well. The revised WMP must assure well integrity is maintained.

Drilling a petroleum well

A petroleum well is drilled as a series of “hole sections”, with the largest diameter section drilled first. This top hole section (first section of a well drilled) may reach depths between 500 and 1200 m below surface, depending on the location of any shallow aquifers. When this section reaches its planned depth, thick steel casing (surface casing) is inserted into the borehole to line it. The casing is cemented in place to the surrounding rock formation and then the wellhead is installed on the surface casing.

BOPs are installed on the wellhead and pressure tested after the first casing is cemented in place. The BOPs are designed to control any liquids or gas under pressure that might emanate from the rock formations that are being drilled. The column of drilling fluid in the well exerts a hydrostatic pressure that helps to balance these pressures. Adjusting the density of the drilling fluid adjusts the hydrostatic pressure exerted to balance formation pressure.

Pressure tests are also conducted on the casing and the cement, and must be passed, before the well is deepened by drilling the next (smaller diameter) hole section and then lining it with the appropriate sized casing. Each casing that is cemented in place will protect the hole that has just been drilled from any downhole pressures that might be encountered in the hole section that is about to be drilled.

This process may occur three or four times depending on the planned total depth (TD) of the well and the rock

formation pressures encountered. The production casing is the last casing, installed from the top of the well down to TD and cemented in place. Each casing extends to, or is “set” and cemented at a different depth within the well with surface casing being shallowest and production casing being deepest. A production liner might be used instead of a full length of production casing, providing overlap from inside the bottom of the previous casing to TD.

At the end of the drilling process, a well will have multiple cemented casings, one inside another. A view from the top would show a series of concentric steel rings with the production casing at the centre. Each concentric ring of casing adds an additional barrier to any movement of fluid from the well into the formation or aquifer, where it is not wanted, or from the formation into the well.

A petroleum well is “completed” by installing tubing inside the production casing from the top of the well down to the hydrocarbon bearing rock formation. Figure 1 is a schematic of a completed well and illustrates the barriers in place, in cross section, both above and below ground. It also illustrates the potential leak paths that will be explained in further detail in the rest of this article. Note that the barriers are in series so that if one barrier fails, fluids will be stopped by the secondary barrier to prevent any leaks.

A packer is a component set near the bottom of the production tubing string to provide isolation of the casing or tubing annulus above the packer from the casing below the packer. The casing below the packer is perforated to allow hydrocarbons to flow from the rock formation into the well. The isolation provided by the packer ensures that the hydrocarbons can only flow to surface (brown arrows in Figure 1) through the tubing.

On completion of drilling a well, the BOP is replaced by a “Christmas tree” (or Xmas tree), so called because of the many valves and tubing extending from it (Fig. 1). A packer fluid that is designed to inhibit

corrosion of the casing is placed in the annulus outside the tubing.

The steel casings that line a well are available in different grades and compositions of steel, with different corrosion resistance and different pressure ratings. The casing selection is based on the anticipated downhole rock formation pressures, the chemistry of formation fluids and the purpose of the well, such as oil or gas production.

Integrity during drilling

The barriers for well control and well integrity maintenance during drilling are BOPs, drilling fluid and casing. Any issue relating to well control, and therefore well integrity, must be reported by the registered holder to DMP.

During the drilling process, drilling activity is monitored through the review of daily reports submitted to DMP. DMP inspectors also conduct on-site audits during drilling to ensure compliance with the approved well management plan, environment plan and safety case. Regular drills are conducted on site to ensure personnel are able to react quickly to any well control issue. BOP pressure tests are done on a prescribed schedule to ensure that the BOPs are capable of controlling downhole pressures.

Integrity during production

The BOP used during drilling is replaced by the Christmas tree before a well can be used for production. The tree is installed on top of the wellhead and connected to the tubing.

Primary barriers in a producing well to prevent leakage of hydrocarbons subsurface are tubing and packers. Secondary barriers subsurface are the casing and cement. At the surface, the primary barriers are the master valves on the Christmas tree. Secondary barriers are the casing annulus valves on the wellhead and the swab and wing valves on the Christmas tree (see Fig. 1).

During production, the flow of hydrocarbons goes from the rock formation through perforations in the casing at the bottom of the well, up

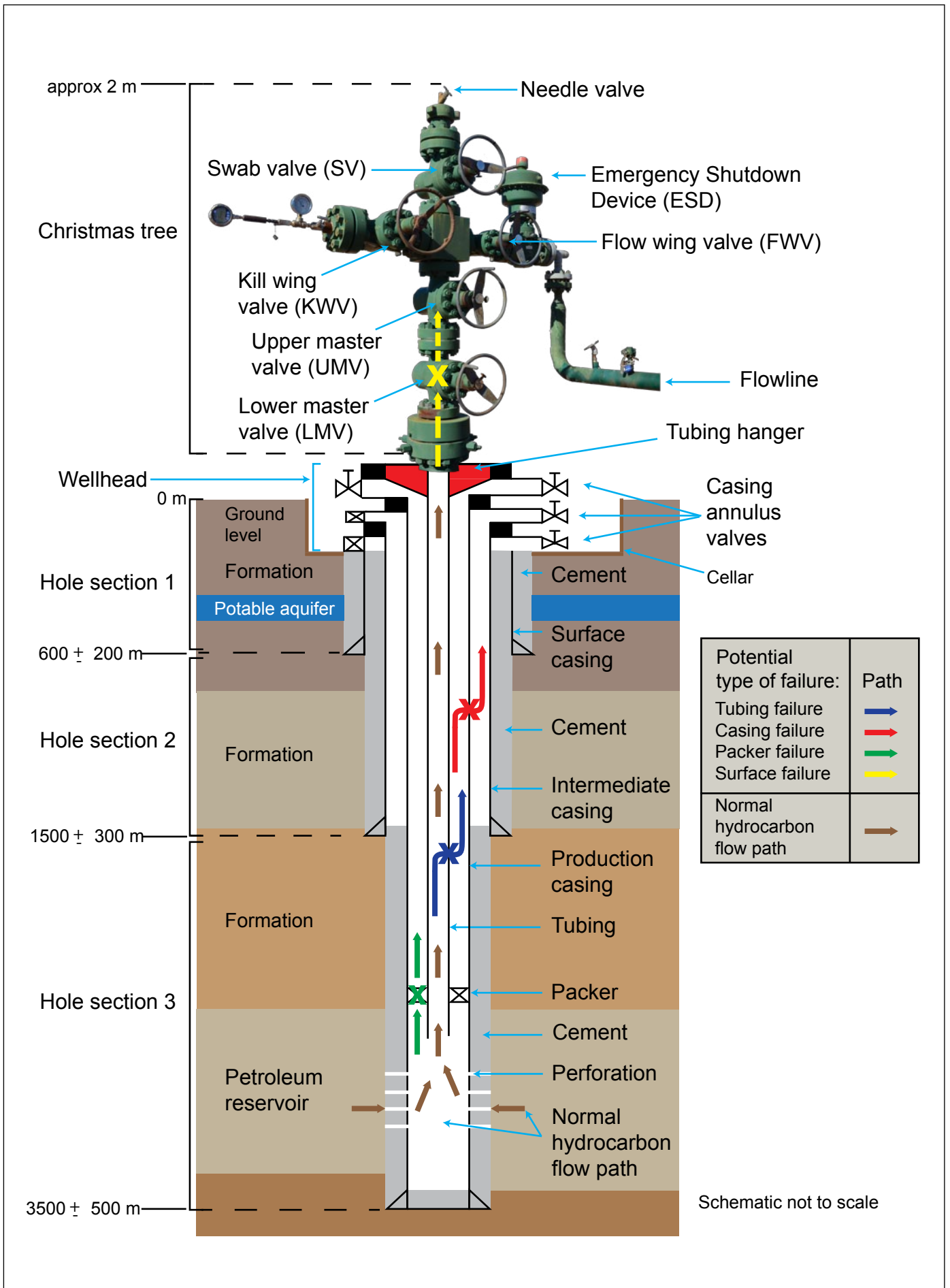


Figure 1. Photograph of a Christmas tree, which is the equipment of an oil or gas production well above ground, sitting on an illustration showing the well's barriers (casing and cement) below ground in cross section (not to scale). Normal hydrocarbon flow is shown by the brown arrows. Potential leak paths are shown in other colours.

into the tubing, from the tubing through the Christmas tree (controlled by the valves in the Christmas tree) and into a flowline (pipeline) that connects to a processing facility.

When a well is shut in, the master valves on the surface Christmas tree are closed. When a well is suspended, a deep-set down-hole isolation device (a mechanical or cement plug) is also installed as a further barrier. If a Christmas tree is temporarily removed to allow maintenance on a well, a deep-set mechanical plug is installed in the tubing as well as a back pressure valve in the wellhead. The intent is to always have two barriers in place no matter the operating status of the well. In this manner, the hydrocarbons are totally enclosed within the well.

When well integrity is maintained, there is neither a hydrocarbon leak into the external environment (surface or subsurface) nor a leak of fluids, such as water, from the external environment into the wellbore.

Maintaining integrity

The responsibility for maintain well integrity lies with the registered holder. DMP requires regular checking of all wells and, if necessary, testing.

Integrity checks involve taking pressure readings on tubing and the casing annuli. Should these readings indicate a potential integrity issue under State regulations, this potential integrity issue must be reported to DMP, investigated and remediated. A well integrity issue occurring means a barrier has failed but does not necessarily mean that well integrity has been breached.

Integrity pressure tests are carried out to ensure that the tubing and casing are still able to hold the pressure which they will be exposed to. A casing annulus pressure gauge reading of zero simply indicates that there is no pressure from the subsurface being exerted at the surface. During a pressure test, high pressure is applied to the casing annulus. If the casing annulus fails to hold the pressure, a barrier failure is indicated. In this example, the well would be shut in and further investigation conducted to determine where the leak has occurred before remediation can be carried out.

Surface valves on the Christmas tree and wellhead are also regularly pressure tested to ensure that they will successfully hold pressure when closed. If a valve fails a test it is replaced.

Production wells usually have tubing and casing pressures electronically monitored and failsafe devices installed that will shut a well in if a problem is detected.

Remediation and decommissioning

DMP must be informed if a well integrity issue occurs. In the event of a primary or secondary barrier failure in a well, DMP requires that the well be shut-in immediately and the barrier repaired or replaced.

Where remediation is feasible it will involve working over a well (workover) to repair the barrier failure. Tubing strings will be replaced by new tubing. Casing leaks might be repaired with a casing patch or with cement squeezed through holes in the casing. Leaking valves will be replaced. Pressure tests are then conducted on the repairs to ensure they have been successful.

In cases where remediation is unlikely to be effective or is too expensive, the well will be decommissioned. The need for decommissioning is a priority for DMP in this situation. Wells will remain shut-in until decommissioned.

Decommissioning a well means isolating hydrocarbon bearing formations from the surface by setting a series of cement plugs as barriers at key points in the well. Each plug is tested before the next plug is set on top of it. The principle of two verified barriers still applies. The plugs must be verified by testing to ensure they conform to international standards before they are accepted as barriers.

The final stage in the life of every well is decommissioning, whether or not integrity issues have occurred. A well might produce hydrocarbons for decades before an oilfield is depleted, and then the well would be decommissioned as it is no longer needed.

Types of barrier failure

There are several ways that barriers can fail. In Figure 1 four potential barrier failures and their resulting leak paths are shown. These four possible barrier failures are described below.

Tubing

Tubing failures are the most common barrier failure due to the constant flow of hydrocarbons and water through them. Corrosion and erosion are the usual causes of tubing failure. Tubing is considered to be a consumable item that will need to be replaced during the life of the well due to wear and tear, in the same way tyres are replaced on cars.

In offshore wells, subsurface safety valves (SSSV) are installed inside the tubing and are activated in an emergency to provide isolation in the well and stop hydrocarbons flowing to the surface. A failure of an SSSV would allow hydrocarbons to flow up tubing to the surface where flow will then be stopped by Christmas tree valves. The SSSVs are considered to be consumable items and are replaced when necessary.

At no time during a tubing leak can hydrocarbons escape the well. A hole in the tubing above the packer will allow hydrocarbons to enter into the casing above the packer, where they will be contained. A tubing failure is detected by an increase in pressure at the casing annulus valve and the well is shut-in until the tubing can be replaced. Figure 1 illustrates a tubing leak path in blue.

Packers

Packers at the bottom of the tubing are also considered to be consumable and might be removed and replaced in a workover operation. A leak in a packer will allow hydrocarbons to pass above the packer into the casing annulus where they will be contained. A failure may be detected by an increase in pressure at the casing annulus valve, in which case the well is shut-in.

Packer failure may be due to other factors than the packer itself.

Recent instances of packer failure were found to be due to:

- the packer being set at the wrong depth such that they were across perforations rather than above or below them. This provided a leak path from inside the casing to outside above the packer and from outside to inside below the packer
- the packer being damaged during further operations – in this case, during a coiled tubing operation
- cheap packers of inferior quality were used and failed pressure tests.

Figure 1 illustrates packer leak paths in green.

Casing

Casing, together with the cement outside, is considered to be a secondary barrier. Casing failures are caused mainly by corrosion but also might occur from mechanical damage. A hole in the casing could allow fluids (water) inside the casing to leak into the external environment subsurface or allow water from the surrounding rock formation to enter into the casing.

Usually when casing fails, the primary barrier is still intact. This means that hydrocarbons in the tubing cannot leak into the casing and therefore cannot leak to the external environment. If the hole occurs in a section of the well where there is a further casing (a third barrier) outside the holed casing then the leak is contained in the further casing. Figure 1 illustrates casing leak paths in red.

Surface equipment

Surface equipment failure is usually when a surface valve fails to hold pressure. If this occurs, the well is shut-in by setting mechanical plugs inside the tubing to close off the flow of hydrocarbons while repairs are carried out. Figure 1 illustrates surface equipment leak paths in yellow.

Reported barrier failures

Statistics for barrier failures in WA during 2015 and 2016 are reported in Table 1. The first two columns are an update on the information

provided in the previous article. The third column shows that the total number of barrier element failures still requiring remediation is 136. This includes wells with barrier element failures reported earlier than 2015 where these wells have not yet been remediated. All of these wells have been shut-in. Factors that have an impact on when a remediation will occur include the need for planning, approval of plans, equipment and personnel availability.

The total number of wells that have been checked for well integrity varies from 1049 to 1053 over this two year period. The variance is due to new wells being drilled and some old wells being decommissioned during the time period.

The data for Figures 2 and 3 is for active (non-decommissioned) wells with barrier failures in WA reported in the 2015 and 2016 calendar years. No cement failures were reported in 2015 and no casing failures were reported in either year.

The data in Figure 4 is for wells with barrier failures that have not yet been remediated (that is, the last column in Table 1). These wells are shown as percentages of the total stock of wells. The wells with barrier failures are shut-in and monitored until such time as equipment is available to remediate them.

The data is sorted by the barrier element that has failed and by the age bracket when the well was drilled. The data collated since the first article in early 2015 indicates a continuation of the same trends reported at that time. The majority of wells have no barrier failures (shown in green).

Tubing or packer failure remains the most common type of well barrier failure in WA in 2015 (Fig. 2) and in 2016 (Fig. 3), and correlates strongly with the age of the well. From Table 1, casing and cement failure (0.2%) is less common than tubing failure (2.2%) but is more likely than a surface barrier failure (0.1%). SSSVs installed in offshore wells have a 0.2% failure rate.

Integrity inspections

DMP inspectors, whenever possible, attend well integrity checks conducted on wells in WA. Checks are conducted on a biannual or annual basis depending on particular circumstances. Reports of all integrity checks are required to be submitted to DMP. DMP analyses the reports for trends.

If anomalies have been noted in the reports, DMP expects further action to be taken to investigate the anomaly. The investigation will determine the appropriate remediation activity to be undertaken. The remedial action is approved and monitored by DMP to ensure that the integrity of wells in our State is maintained.

Table 1. Barrier elements failure reported in 2015 and 2016

Barrier elements failure	Integrity issue reported – 2015	Integrity issue reported – 2016	Non-remediated wells at December 2016
Tubing/Packer	20	23	83
Casing	0	0	33
Cement	0	2	10
SSSV	2	2	2
Wellhead	1	1	8
Total elements	23	28	136*
Total number of inspected wells	1049	1053	1053

*Includes wells with integrity issues reported prior to 2015

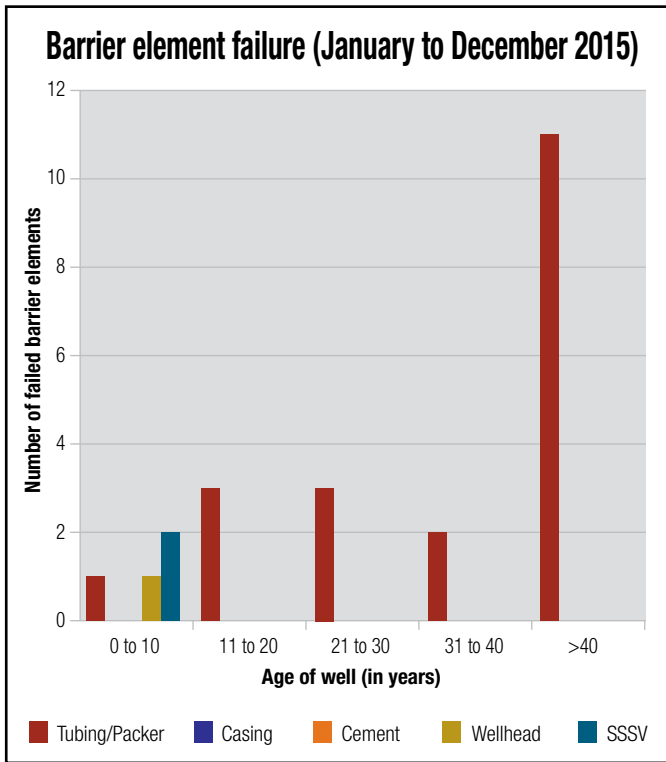


Figure 2. Barrier element failure in 2015 relative to age of wells

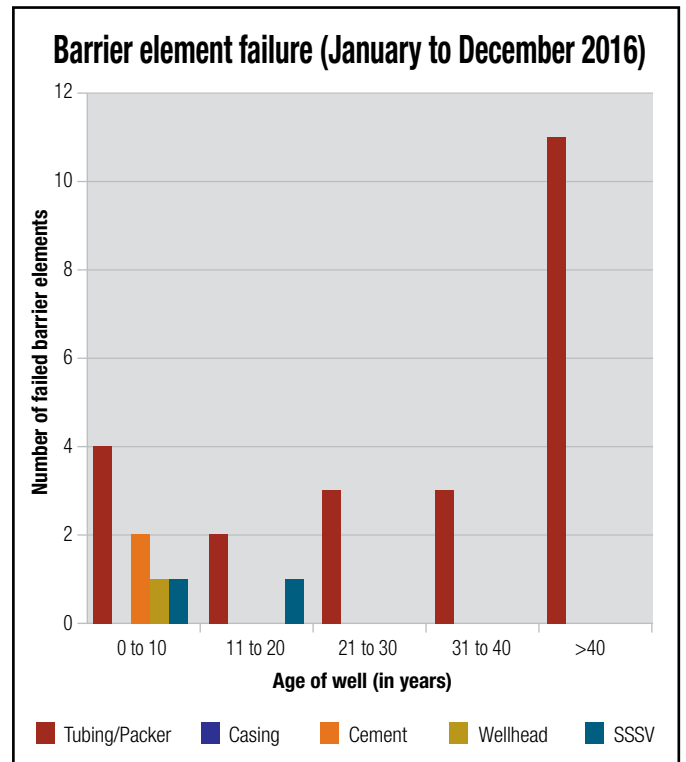


Figure 3. Barrier element failure in 2016 relative to age of wells

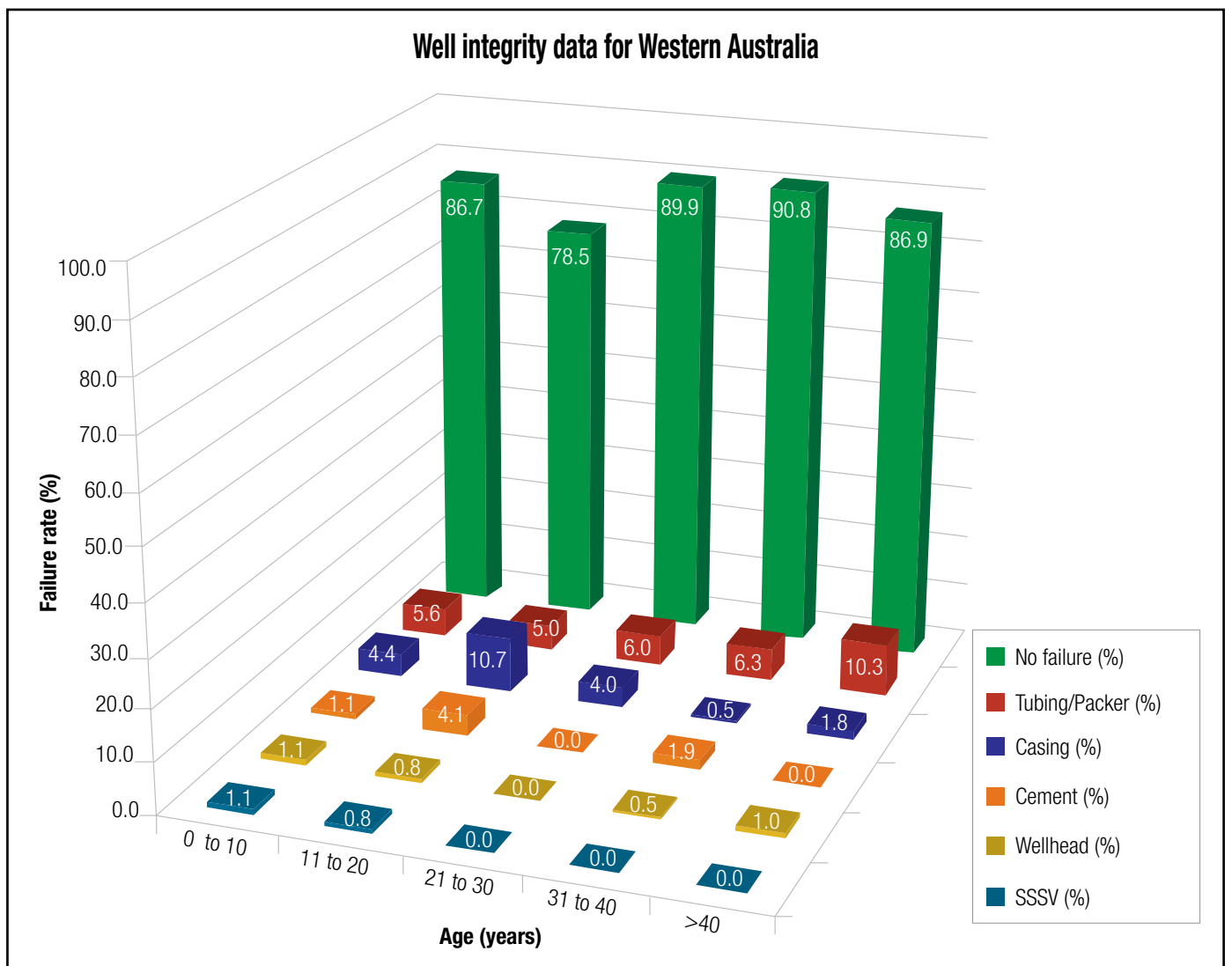


Figure 4. Percentage of shut-in wells with non-remediated barrier failure in Western Australia at December 2016 compared to number of wells inspected per age bracket

The 1920s oil boom in Western Australia

Colin Harvey

Principal Legislation and Policy Officer
Petroleum Division

MAP OF WESTERN AUSTRALIA. OIL AREAS ACQUIRED BY COMPANIES.				
No.	Original Lessee.	Name of Company.	Capital.	Office.
1b 10b 20b	Stevens O'Donnell Rusdie	Australiat Petroleum Development Co. N.L. The Company are also holders of 4 areas in the Northern Territory	£20,000 1,250 shares at £20. New Coy. in process of formation (W.A. Kimberley Oil Co. N.L.) £400,000—400,000 shares at £1	Regd. Office, 84 Queen St., Perth. Manager, A. Parsons. Regd. Attorney, W. J. Biddle, 10 A.M.P. Chambers, Perth.
2b 3b	M. Freney M. Freney	The Freney Kimberley Oil Coy. Limited	£150,000 150,000 shares at £1-0-0 each	Regd. Office, 11-15 Weld Chambers, Perth. Secretary, W. A. Carney, A.S.A.A., A.I.C.A. & A.A.I.S.
32b	Okes	Okes-Durack Kimberley Oil Coy. No Liability	£250,000 250,000 shares at £1-0-0 each	Regd. Office, Weld Chs., Perth. Secy., J. P. Baskin, F.C.P.A. & F.C.I.S.
30b	Le Mesurier	Edna May Golden Points Gold Mining Coy., N.L.	£50,000 100,000 shares at 10/- each	Regd. Office, Brookman's Bldgs., Adelaide S.A. Secy., T. S. Wilson, Regd. Attorney.
33b	Baird	Kimberley Oil Options Coy., N.L.	£25,000 100,000 shares at 5/- each 50,000 issued to Public at 1/- each 50,000 held in Reserve	Regd. Office, Brookman's Bldgs., Adelaide S.A. Secy., T. S. Wilson, Regd. Attorney.
31b	Carvay	Lau O'George Edut G.M. Coy., N.L.	£150,000. 150,000 shares at £1 each. No shares in Reserve. 150,000 issued and paid to Co. Coy. purpose issuing 35,000 new shares at £1.	Regd. Office, Brookman's Bldgs., Adelaide S.A. Secy., C. S. Stokes.
30b	Locke	Locke Oil Development Co., Ltd.	£12,000 240 shares at £50 each (fully paid) 120 shares issued to Public 120 shares issued to Vendor	Regd. Office, 14 Martin Place, Sydney, N.S.W. Secy., H. C. Carter. Registered Attorney, A. Locke, No. 10 Bank N.S.W. Chs., Perth.
33b	Ender	Peruatty Consoh Gold Mining Co. No Liability	£80,000 130,000 shares at 10/- each	Regd. Office, Brookman's Bldgs., Adelaide S.A. Secy., T. S. Wilson, Regd. Attorney.
30b	Mellor	Messorco Extended G.M. Coy. N.L.	£5,000 70,000 shares at 10/- each	Regd. Office, Brookman's Bldgs., Adelaide S.A. Secy., T. S. Wilson, Regd. Attorney.
31b 42b	Thomas Hunter	Murchison Petroleum Coy. N.L. (in process of formation)	£200,000 200,000 shares at £1-0-0 each	Propd. Regd. Office, 10 A.M.P. Chs., Perth. Secy., A. J. Love.
14b 17b	Perkins & Party	South-Western Oil & Shale Co., N.L. N.L.—Proposed New Coy. Pallinup Oil & Shale Coy., N.L. (now in process of formation)	£15,000. 3,000 shares at £5 each £150,000 15,000 shares at £1 each	Regd. Office, 35 Collins St., Perth. Vico. Manager, E. J. Kennedy. Regd. Attorney, Western Australia, Sir William Lathian, Perth.
30b 30a 30b 30c 30d 30e 30f 30g 30h 30i 30j 30k 30l 30m 30n 30o 30p 30q 30r 30s 30t 30u 30v 30w 30x 30y 30z		W.A. Oil Exploration Coy., Ltd.	£21,000 70 shares at £100 each 1,400 shares at £10 each	Regd. Office, 50 St. George's Terr., Perth. W.A. Secy., Christopher Hunter.
71b		Leuwini Oil Prospecting Coy. Ltd. N.L.—Also holders of P.P. Struck Locations 2300, 1211, & 1251	£2,000 2,000 shares at £1-0-0 each	Regd. Office, 70 A.M.P. Chs., Perth., W.A. Secy., A. E. Weston.

Oil permits circa 1920

Although the first signs of oil in Western Australia (WA) were reported in the early 1900s on the State's south coast in the Warren River area, it was in the Kimberley during the years following the First World War that petroleum exploration commenced on a serious basis.

Between 1919 and 1924, WA experienced an oil boom across the whole of the State. The boom was driven by initial discoveries and access to capital and geological expertise. Commonwealth and State Government financial incentives also had a significant influence, as well as availability of drilling equipment, to core and drill deep wells, and access to local chemical analysis, capable of verifying discoveries.

Early discoveries and reconnaissance

The first discoveries of petroleum were reported with two separate finds in the east and west Kimberley. In 1919, a stockman, Walter Okes reported finding glance/pitch in basalt near the junction of the Negri and Ord Rivers in the East Kimberley. (Glance/pitch is a derivative of mineral oil with an asphaltic base.) This discovery was later confirmed by the Western Australian Geological Survey's Geologist, T Blatchford, in 1922, when samples were tested in Perth, and led to the formation of the

Okes-Durack Kimberley Company. The discovery area was geologically examined in 1922 by D J Mahoney, the Government Petrologist of the Victorian Geological Survey, engaged by the Okes-Durack company with the Victorian Government's permission. Mahoney's work led to the company drilling a bore to depth of 364.5 m (1196 ft) on the east side of the Ord River, 48 km south of the Negri-Ord junction. From 240 m (788 ft) onwards, the bore passed through basalt and gas and a "petroliferous and sulphurous odour" was noticed.

Also in 1919 in the West Kimberley, water drilling contractor, Harry Price obtained traces of oil while hand

boring a water well on Gogo Station, south of Fitzroy Crossing. Price reported his find to a soft goods trader, George Freney. This find was also later confirmed by Blatchford in 1922. Freney formed the Freney Kimberley Company and began geological work and drilled four test bores near Price's original discovery, ranging in depth from 103 to 329 m (340 to 1080 ft). All four wells showed traces of oil. This work was supervised by Blatchford, on loan to the company from the Geological Survey of Western Australia.

Geological surveying continued in the Fitzroy Basin by the Geological Survey's Blatchford and Talbot. This



Banks Collection of Photographs – Oil rig team at Poole Range

Photo © State Library of Western Australia 005759D



Photo © State Library of Western Australia BA767_1

Images of the Locke Expedition – The Locke Oil Expedition, 1922

work led to the selection of a site near Mount Wynne and two wells were drilled to a depth of 273 m and 656 m (896 ft and 2154 ft), respectively. Both wells logged petroleum residues, globules of oil and bituminous material.

Exploration was also occurring elsewhere in the State. In 1922, the New South Wales funded Locke Oil Expedition travelled along the Canning Stock Route from Leonora to Halls Creek. Led by geologist L A Jones, the aim of the expedition was to carry out a geological reconnaissance of oil Holding Block 25H (see map). Jones and his team wanted to ascertain whether the geological formations in the area were suitable for the storage and retention of petroleum, and to locate a site for boring operations.

In the Carnarvon Basin area, reconnaissance work was undertaken in 1924 by Dr Clapp, an American geologist, and Dr Morgan at Rough Range on Exmouth Gulf Station. The *Sunday Times* was

sceptical of the value of Clapp's work and his later pessimistic report on the likelihood of finding oil in the Kimberley was not well received.

Oil titles for exploration

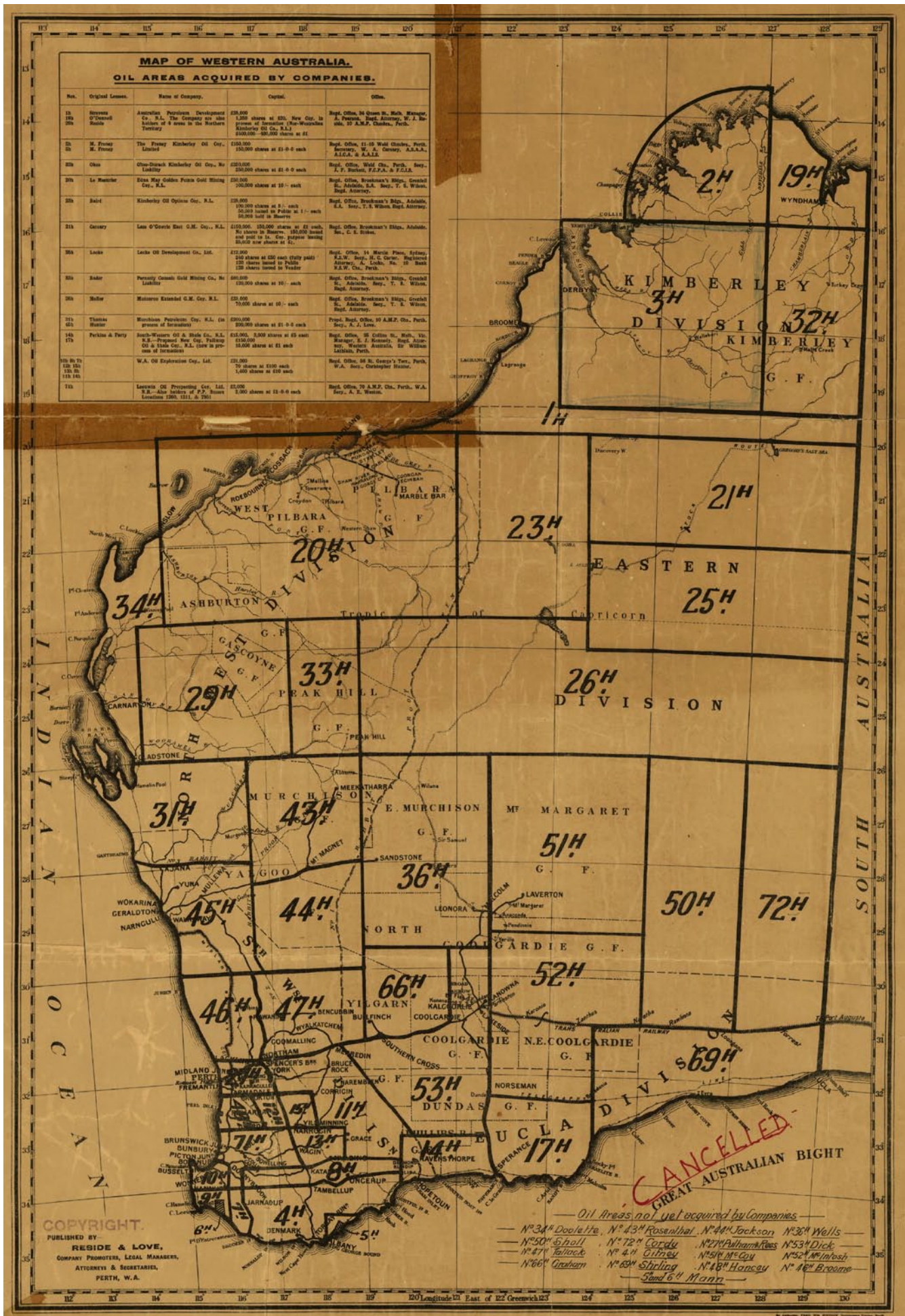
Demand for oil permits meant that even prior to amendments to the *Mining Act 1904*, the mining legislation was used as a vehicle for oil exploration tenure. Such was the level of activity, (as shown on the map), that in 1919, the State was completely covered by 13 Oil Permits to Explore (OPEs). WA based companies held five of these, with five held by SA companies, two Victorian and one from NSW. This degree of local investment capital and speculation was reminiscent of colonial investment in sealing, whaling and the early mining industry before overseas capital took an interest. While the titles were held in the name of a registered company, it did allow for the practice of unlisted companies negotiating working options over portions of the few

larger oil titles. Early involvement of Kimberley pastoralists in the oil industry also points to the degree of influence station owners played in the local economy.

Following lobbying of the Minister for Mines John Scadden, the mining legislation was amended in late 1920 with the insertion of a new Part Va covering 'mineral oil leases' with rights in oil reserved to the Crown. Questions had been raised in State Parliament over concerns that the Commonwealth could declare petroleum a monopoly in the Empire's interest. Whether these concerns were imagined or real, passage of the 'Oil Bill' safeguarded the State's interests. By 1921, the number of oil permits reached 53, but by 1924 numbers declined, as surrenders and cancellations increased.

Available drilling technology

From the 1880s, the pastoral industry was increasingly reliant on supplies of artesian water obtained from deep bores drilled



Map of Western Australia circa 1920 – oil areas acquired by companies

into aquifers to supplement rainfall and access to creeks and rivers for watering stock. The percussion and rotary technology to drill deep bores was available to open up more land for pastoral leases to run sheep and cattle. Like their eastern counterparts, WA pastoralists invested in water bores as a means of increasing grazing areas.

The rise in the cost of diamonds used for diamond drilling bits encouraged experiments in using other materials, including hard metals. This work led to a little known Australian invention – the calyx drill. This type of drill, similar to a diamond drill, was invented by Queenslander, Frank Davis, in 1893. The drilling bit was made of hardened steel set on a water fed hollow drilling rod, above which a cylindrical chamber or ‘calyx’ collected rock samples in addition to the core. This aspect of the calyx drill was important when the strata were too soft to provide useful cores. The calyx drilling unit was a major improvement for drilling artesian wells and was used in early oil exploration drilling in WA by the Freney Kimberley Company and possibly other explorers.

Other factors encourage WA oil exploration

Both immediately before and during the war, access to oil was recognised as crucial for naval defence and to fuel the merchant fleet, as oil replaced coal as the main maritime fuel. Although coal and wood powered steam was still a dominant source of energy onshore in Australia, the use of petrol became increasingly important. The distance from international markets and the recent German naval activity in the Indian and Pacific Ocean areas helped encourage the search for oil at national and state level.

During the war, Prime Minister Billy Hughes had warned of the dangers of reliance on oil imports. This concern led to the Commonwealth Government offering a £20,000 reward in 1920 for the commercial discovery of oil in Australia. Within months, this figure was increased to £50,000. Commonwealth support for oil exploration continued under Hughes’ successor, Stanley Bruce, throughout the 1920s.

This Commonwealth Government financial incentive for oil was matched in part by the State Government. In addition, WA in common with many of the other states had established a colonial geological survey with an economic focus, which although initially focussed on gold, was equipped to search for a wide range of minerals, with a professional staff of geologists, including a petrologist. The State Government had also set up a chemical analytical laboratory in Perth capable of verifying mineral discoveries.

By 1924, the number of permits in WA declined as no new discoveries were found. Although the initial boom began to subside, companies such as Freney continued to raise capital and carried out drilling operations in the Kimberley during the rest of the decade.

Footnote:

This brief overview of the early history of the oil industry in Western Australia is the first in an occasional series planned to cover the period from 1919 – 1956. Any feedback or suggestions for additional sources and pictures for this period are welcomed. Please email colin.harvey@dmp.wa.gov.au



Photo © State Library of Western Australia BA2595_35

Standard Oil exploration party led by American experts Dr Clapp (in pith helmet on the left) and Dr Morgan (in pith helmet on right) at Rough Range on Exmouth Gulf Station in 1924. It is at this site Standard Oil sunk their successful well in 1953.

Petroleum statistics and titles tables

TABLE 1. 2015 PRODUCTION BY FIELD AND CUMULATIVE PRODUCTION WA ONSHORE AND STATE WATERS – FROM 1 JANUARY TO 31 MAY 2015

Field	Operator	January to May 2015 production by field			Cumulative production to 31 May 2015			Permit
		Oil	Condensate	Gas	Oil	Condensate	Gas	
		kL	kL	10 ³ m ³	kL	kL	10 ³ m ³	
Bambra	Quadrant	16,311.40	23.10	5,504.40	455,075.50	158,479.40	1,389,057.60	TL/1
Barrow Island	Chevron	111,533.00	0.00	12,186.00	51,596,621.93	0.00	5,448,523.80	L1H
Beharra Springs	Origin	0.00	11.50	1,267.50	0.00	26,615.67	2,525,888.16	L11
Corybas	AWE	0.00	26.56	1,096.69	0.00	438.67	23,395.96	L2
Dongara	AWE	135.10	0.00	4,845.44	195,931.54	49,681.21	12,961,090.28	L1, L2
Hovea	AWE	0.00	0.00	97.30	1,170,005.35	251.09	105,015.46	L1
Linda	Quadrant	3,531.00	464.60	34,916.20	3,879.80	301,945.10	1,242,960.00	TL/1
Red Gully	Empire	0.00	7,948.30	31,636.78	0.00	29,700.00	106,683.31	L18, L19
Redback	Origin	0.00	103.10	50,257.90	0.00	1,018.54	632,811.11	L11
Rose	Quadrant	8,114.80	629.10	64,339.40	38,650.90	212,641.40	1,276,019.10	TL/1
Tarantula	Origin	0.00	142.30	14,861.20	0.00	4,365.53	357,471.90	L11
Ungani	Buru	2,620.00	0.00	2.48	72,908.00	0.00	58.40	L20, L21
Total		142,245.30	9,348.56	221,011.28				

Notes:

1. Petroleum production in Western Australia started as early as 1955 from the Rough Range oilfield, however, large scale petroleum production did not start until the Barrow Island oilfield came online in the 1960s.
2. As of May 2015, there have been 71 producing oil- and gasfields in the State. Of these, 35 fields are now depleted and have ceased production.
3. During January to May 2015, 12 fields were on production and 24 fields were temporarily shut in. Wells shut in during this period were: Agincourt, Apium, Blina, Boundary, Double Island, Eremia, Evandra, Gingin West, Harriet, Jingemia, Lee, Little Sandy, Lloyd, North Alkimos, Pedirka, Rough Range, Simpson, South Plato, Sundown, Victoria, West Cycad, Wonnich, Xyris and Xyris South.
4. As of 31 May 2015, the cumulative production of fields from onshore WA and WA State waters was 96.8 GL of oil, 47.7 Gm³ of gas, and 2.2 GL of condensate.

**TABLE 2A. PETROLEUM RESERVES AND RESOURCES ESTIMATES IN WA JURISDICTIONS
(SI UNITS, VALID AS OF 31 DECEMBER 2015)**

Basin	Reserves						Contingent Resources*					
	Oil, GL		Gas, Gm ³		Condensate, GL		Oil, GL		Gas, Gm ³		Condensate, GL	
	1P	2P	1P	2P	1P	2P	1C	2C	1C	2C	1C	2C
Browse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	197.51	N/A	20.40
Canning	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.95	1.76	5.54	0.16	0.48
Carnarvon	1.46	7.89	0.15	0.69	0.01	0.03	1.34	2.21	0.38	1.00	0.05	0.13
Perth	0.00	0.00	3.39	6.61	0.01	0.01	0.00	0.00	47.70	58.35	0.33	0.49
WA Total	1.46	7.89	3.54	7.30	0.02	0.04	1.93	3.16	49.83	262.40	0.54	21.50

**TABLE 2B. PETROLEUM RESERVES AND RESOURCES ESTIMATES IN WA JURISDICTIONS
(IMPERIAL UNITS, VALID AS OF 31 DECEMBER 2015)**

Basin	Reserves						Contingent Resources*					
	Oil, MMstb		Gas, Bscf		Condensate, MMstb		Oil, MMstb		Gas, Bscf		Condensate, MMstb	
	1P	2P	1P	2P	1P	2P	1C	2C	1C	2C	1C	2C
Browse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	6,974.93	N/A	128.34
Canning	0.02	0.02	0.00	0.00	0.00	0.00	3.69	5.97	62.01	195.74	1.01	3.00
Carnarvon	9.17	49.67	5.39	24.37	0.08	0.21	8.42	13.89	13.42	35.47	0.29	0.82
Perth	0.00	0.00	119.99	233.76	0.05	0.09	0.00	0.00	1,684.40	2,060.37	2.08	3.07
WA Total	9.19	49.69	125.38	258.13	0.13	0.30	12.11	19.86	1,759.83	9,266.51	3.37	135.23

Note: Browse Basin contingent resources have been updated since the last issue of PWA (September 2016)

**TABLE 3. PETROLEUM WELLS IN WESTERN AUSTRALIA
– ONSHORE AND STATE WATERS 2016 CALENDAR YEAR**

Well Name	Class	On Off	Title	Operator	Latitude	Longitude	Spud Date	TD Date	Rig Release Date
CANNING BASIN									
Ungani Far West 1	NFW	On	L 21	Buru Energy Limited	-18.000	123.134	28/12/2015	31/01/2016	09/02/2016
PERTH BASIN									
Mondarra 9	STO	On	L1	APA Group	-29.313	115.117	05/01/2016	25/01/16	04/02/2016
NORTHERN CARNARVON BASIN									
TGS 1	STO	On	L9	DDG Tubridgi	-21.772	114.850	22/11/2016	29/11/2016	11/12/2016
TGS 4	STO	On	L9	DDG Tubridgi	-21.764	114.849	14/12/2016		25/12/2016

TABLE 4. WELL ACTIVITY APPROVALS

Financial year (July to June)	Well activity applications	Approved	On hold	Under assessment	Refused	Lapsed	Average days to approve	Comment
2012–13	18	18				3	20	New well applications – 18
2013–14	45	44			1		12.9	New well applications – 16; 1 refused
2014–15	109	109					15.6	New well applications – 18; submissions – 91
2015–16	284	228	56				15	New well applications – 8
2016–17*	72	109	1	19			16.4	New well applications – 10

* As at 14 March 2017

These statistics are based on data obtained from the Petroleum Geothermal Register (PGR). Post-drilling activity submissions were not approved through PGR until part way through the 2013–14 financial year. Previously, such submissions were approved but the approvals were not recorded in PGR.

On 1 July 2015 the petroleum Resource Management and Administration Regulations came into force. Transition of the regulations ended on 1 July 2016. Wells regulated under the *Petroleum and Geothermal Energy Resources Act 1967* and the *Petroleum (Submerged Lands) Act 1982* are required to have an approved well management plan that covers what is currently occurring on these wells. Subsequent activity on a well requires a separate approval as a revision to the well management plan.

The number of days required to assess and approve an application does not include the ‘on hold’ time waiting for more information before assessment can be completed. The on hold process occurs when either DMP needs more information to assess the application or the registered holder requests for an application to be put on hold and the assessment deferred. One on hold request was for a well management plan with incomplete information.

TABLE 5. LIST OF PETROLEUM TITLES AND HOLDERS IN WESTERN AUSTRALIAN JURISDICTIONS AS AT 9 FEBRUARY 2017

PETROLEUM (SUBMERGED LANDS) ACT 1982

Exploration Permit

Title	Registered Holder(s)
TP/7 R4	HYDRA ENERGY (WA) PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD TAP (SHELFAL) PTY LTD
TP/8 R4	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TP/15 R2	WESTRANCH HOLDINGS PTY LTD
TP/25	FINDER NO 3 PTY LIMITED
TP/27	CARNARVON PETROLEUM LIMITED
TP/28	CONOCOPHILLIPS (BROWSE BASIN) PTY LTD ORIGIN ENERGY BROWSE PTY LTD PETROCHINA INTERNATIONAL INVESTMENT (AUSTRALIA) PTY LTD

PETROLEUM (SUBMERGED LANDS) ACT 1982

Pipeline Licence

Title	Registered Holder(s)
TPL/1 R1	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TPL/2 R1	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TPL/3 R1	HYDRA ENERGY (WA) PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD TAP (SHELFAL) PTY LTD
TPL/4 R1	HYDRA ENERGY (WA) PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD TAP (SHELFAL) PTY LTD
TPL/5 R1	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TPL/6 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
TPL/7 R2	HYDRA ENERGY (WA) PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD TAP (SHELFAL) PTY LTD
TPL/8	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TPL/9 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
TPL/10	BHP BILLITON PETROLEUM (AUSTRALIA) PTY LTD* INPEX ALPHA LTD MOBIL EXPLORATION & PRODUCING AUSTRALIA PTY LTD
TPL/11	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD

TPL/12	QUADRANT EAST SPAR PTY LIMITED QUADRANT KERSAIL PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD
TPL/13	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT EAST SPAR PTY LIMITED QUADRANT KERSAIL PTY LTD QUADRANT NORTHWEST PTY LTD* QUADRANT OIL AUSTRALIA PTY LIMITED SANTOS (BOL) PTY LTD
TPL/14	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TPL/15	BHP BILLITON PETROLEUM (NORTH WEST SHELF) PTY LTD BP DEVELOPMENTS AUSTRALIA PTY LTD CHEVRON AUSTRALIA PTY LTD JAPAN AUSTRALIA LNG (MIMI) PTY LTD SHELL AUSTRALIA PTY LTD WOODSIDE ENERGY LTD*
TPL/16	BHP BILLITON PETROLEUM (NORTH WEST SHELF) PTY LTD BP DEVELOPMENTS AUSTRALIA PTY LTD CHEVRON AUSTRALIA PTY LTD JAPAN AUSTRALIA LNG (MIMI) PTY LTD SHELL AUSTRALIA PTY LTD WOODSIDE ENERGY LTD*
TPL/17	QUADRANT NORTHWEST PTY LTD* SANTOS (BOL) PTY LTD
TPL/18	A.C.N. 008 939 080 PTY LTD A.C.N. 008 988 930 PTY LTD ROC OIL (WA) PTY LIMITED*
TPL/19	KANSAI ELECTRIC POWER AUSTRALIA PTY LTD TOKYO GAS PLUTO PTY LTD WOODSIDE BURRUP PTY LTD*
TPL/20	QUADRANT NORTHWEST PTY LTD* SANTOS OFFSHORE PTY LTD
TPL/21	CHEVRON (TAPL) PTY LTD* JERA GORGON PTY LTD MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED OSAKA GAS GORGON PTY LTD SHELL AUSTRALIA PTY LTD TOKYO GAS GORGON PTY LTD
TPL/22	CHEVRON (TAPL) PTY LTD* JERA GORGON PTY LTD MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED OSAKA GAS GORGON PTY LTD SHELL AUSTRALIA PTY LTD TOKYO GAS GORGON PTY LTD
TPL/23	BHP BILLITON PETROLEUM (AUSTRALIA) PTY LTD* QUADRANT PVG PTY LTD
TPL/24	CHEVRON (TAPL) PTY LTD* JERA GORGON PTY LTD MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED OSAKA GAS GORGON PTY LTD SHELL AUSTRALIA PTY LTD TOKYO GAS GORGON PTY LTD
TPL/25	CHEVRON (TAPL) PTY LTD* KUFPEC AUSTRALIA (JULIMAR) PTY LTD KYUSHU ELECTRIC WHEATSTONE PTY LTD PE WHEATSTONE PTY LTD SHELL AUSTRALIA PTY LTD WOODSIDE ENERGY JULIMAR PTY LTD

TABLE 5. LIST OF PETROLEUM TITLES AND HOLDERS IN WESTERN AUSTRALIAN JURISDICTIONS AS AT 9 FEBRUARY 2017

PETROLEUM (SUBMERGED LANDS) ACT 1982

Production Licence

Title	Registered Holder(s)
TL/1 R1	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TL/2 R1	HYDRA ENERGY (WA) PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD TAP (SHELFAL) PTY LTD
TL/3 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
TL/4 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
TL/5 R1	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TL/6 R1	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TL/7	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
TL/8	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TL/9	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
TL/10	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*

PETROLEUM (SUBMERGED LANDS) ACT 1982

Retention Lease

Title	Registered Holder(s)
TR/3 R2	QUADRANT NORTHWEST PTY LTD
TR/4 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
TR/5 R2	BP DEVELOPMENTS AUSTRALIA PTY LTD JAPAN AUSTRALIA LNG (MIMI BROWSE) PTY LTD PETROCHINA INTERNATIONAL INVESTMENT (AUSTRALIA) PTY LTD SHELL AUSTRALIA PTY LTD WOODSIDE BROWSE PTY LTD*
TR/6 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD

PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967

Access Authority

Title	Registered Holder(s)
AA 5	FINDER NO 5 PTY LIMITED

PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967

Exploration Permit

Title	Registered Holder(s)
EP 61 R7	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
EP 62 R7	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
EP 104 R6	GULLIVER PRODUCTIONS PTY LTD* INDIGO OIL PTY LTD
EP 129 R6	BURU ENERGY LIMITED
EP 307 R6	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
EP 320 R5	AWE (BEHARRA SPRINGS) PTY LTD ORIGIN ENERGY DEVELOPMENTS PTY LIMITED*
EP 321 R4	ALCOA OF AUSTRALIA LIMITED LATENT PETROLEUM PTY LTD*
EP 358 R3	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
EP 359 R3	BOUNTY OIL & GAS NL LANSVALE OIL & GAS PTY LTD PACE PETROLEUM PTY LTD PHOENIX RESOURCES LTD ROUGH RANGE OIL PTY LTD
EP 368 R4	EMPIRE OIL COMPANY (WA) LIMITED* WESTRANCH HOLDINGS PTY LTD
EP 371 R2	BURU ENERGY LIMITED DIAMOND RESOURCES (CANNING) PTY LTD
EP 386 R3	ONSHORE ENERGY PTY LTD
EP 389 R2	EMPIRE OIL COMPANY (WA) LIMITED
EP 391 R3	BURU ENERGY LIMITED* DIAMOND RESOURCES (FITZROY) PTY LTD
EP 408 R2	CALENERGY RESOURCES (AUSTRALIA) LIMITED* WHICHER RANGE ENERGY PTY LTD
EP 413 R3	AWE PERTH PTY LTD BHARAT PETRORESOURCES LIMITED NORWEST ENERGY NL*
EP 416 R2	EMPIRE OIL COMPANY (WA) LIMITED PILOT ENERGY LIMITED*
EP 426 R2	EMPIRE OIL COMPANY (WA) LIMITED* WESTRANCH HOLDINGS PTY LTD
EP 428 R1	BURU ENERGY LIMITED DIAMOND RESOURCES (CANNING) PTY LTD
EP 430 R1	EMPIRE OIL COMPANY (WA) LIMITED
EP 431 R1	BURU ENERGY LIMITED* DIAMOND RESOURCES (FITZROY) PTY LTD
EP 432 R1	EMPIRE OIL COMPANY (WA) LIMITED*
EP 435 R1	AUSTRALIAN OIL COMPANY NO 3 PTY LIMITED BLACK FIRE MINERALS LIMITED BOUNTY OIL & GAS NL PHOENIX RESOURCES LTD ROUGH RANGE OIL PTY LTD
EP 436 R1	BURU ENERGY LIMITED* DIAMOND RESOURCES (FITZROY) PTY LTD

TABLE 5. LIST OF PETROLEUM TITLES AND HOLDERS IN WESTERN AUSTRALIAN JURISDICTIONS AS AT 9 FEBRUARY 2017

EP 437 R1	CARACAL EXPLORATION PTY LTD KEY PETROLEUM (AUSTRALIA) PTY LTD REY OIL AND GAS PERTH PTY LTD
EP 440 R1	EMPIRE OIL COMPANY (WA) LIMITED
EP 447 R1	GCC METHANE PTY LTD UIL ENERGY LTD*
EP 454 R1	EMPIRE OIL COMPANY (WA) LIMITED*
EP 455 R1	AWE PERTH PTY LTD* TITAN ENERGY LTD
EP 457 R1	BURU FITZROY PTY LTD* DIAMOND RESOURCES (FITZROY) PTY LTD REY OIL AND GAS PTY LTD
EP 458 R1	BURU FITZROY PTY LTD* DIAMOND RESOURCES (FITZROY) PTY LTD REY OIL AND GAS PTY LTD
EP 469	WARREGO ENERGY PTY LTD*
EP 475	CARNARVON PETROLEUM LIMITED
EP 480	EMPIRE OIL COMPANY (WA) LIMITED PILOT ENERGY LIMITED*
EP 481	NEW STANDARD ONSHORE PTY LTD
EP 482	NEW STANDARD ONSHORE PTY LTD
EP 483	FINDER NO 3 PTY LIMITED
EP 487	OIL BASINS LIMITED REY LENNARD SHELF PTY LTD*
EP 488	UIL ENERGY LTD
EP 489	UIL ENERGY LTD
EP 490	CARNARVON PETROLEUM LIMITED
EP 491	CARNARVON PETROLEUM LIMITED
EP 493	FINDER SHALE PTY LIMITED
EP 494	MACALLUM GROUP LTD* SOUTHERN SKY ENERGY PTY LTD
EP 495	OCEANHILL PTY LTD

L 9 R1	DDG TUBRIDGI PTY LIMITED
L 10 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
L 11	AWE (BEHARRA SPRINGS) PTY LTD ORIGIN ENERGY DEVELOPMENTS PTY LIMITED*
L 12	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
L 13	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
L 14	AWE PERTH PTY LTD GEARY, JOHN KEVIN NORWEST ENERGY NL ORIGIN ENERGY RESOURCES LIMITED ROC OIL (WA) PTY LIMITED
L 15	GULLIVER PRODUCTIONS PTY LTD* INDIGO OIL PTY LTD
L 16	AUSTRALIAN OIL COMPANY NO 3 PTY LIMITED BOUNTY OIL & GAS NL ROUGH RANGE OIL PTY LTD
L 17	BURU ENERGY LIMITED
L 18	EMPIRE OIL COMPANY (WA) LIMITED*
L 19	EMPIRE OIL COMPANY (WA) LIMITED*
L 20	BURU ENERGY LIMITED* DIAMOND RESOURCES (FITZROY) PTY LTD
L 21	BURU ENERGY LIMITED* DIAMOND RESOURCES (FITZROY) PTY LTD

**PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967
Petroleum Lease**

Title	Registered Holder(s)
L 1H R2	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD

**PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967
Production Licence**

Title	Registered Holder(s)
L 1 R1	APT PARMELIA PTY LTD AWE PERTH PTY LTD* ORIGIN ENERGY DEVELOPMENTS PTY LIMITED
L 2 R1	AWE PERTH PTY LTD* ORIGIN ENERGY DEVELOPMENTS PTY LIMITED
L 4 R1	AWE PERTH PTY LTD
L 5 R1	AWE PERTH PTY LTD
L 6 R1	BURU ENERGY LIMITED
L 7 R1	AWE PERTH PTY LTD
L 8 R1	BURU ENERGY LIMITED

**PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967
Retention Lease**

Title	Registered Holder(s)
R 1 R2	GULLIVER PRODUCTIONS PTY LTD* INDIGO OIL PTY LTD
R 2 R2	BP DEVELOPMENTS AUSTRALIA PTY LTD JAPAN AUSTRALIA LNG (MIMI BROWSE) PTY LTD PETROCHINA INTERNATIONAL INVESTMENT (AUSTRALIA) PTY LTD SHELL AUSTRALIA PTY LTD WOODSIDE BROWSE PTY LTD*
R 3 R1	OIL BASINS LIMITED
R 4 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
R 6	ALCOA OF AUSTRALIA LIMITED LATENT PETROLEUM PTY LTD*
R 7	ALCOA OF AUSTRALIA LIMITED LATENT PETROLEUM PTY LTD*

**PETROLEUM AND GEOTHERMAL ENERGY RESOURCES ACT 1967
Special Prospecting Authority**

Title	Registered Holder(s)
SPA 20 AO	GULLIVER PRODUCTIONS PTY LTD

TABLE 5. LIST OF PETROLEUM TITLES AND HOLDERS IN WESTERN AUSTRALIAN JURISDICTIONS AS AT 9 FEBRUARY 2017

PETROLEUM PIPELINE ACT 1969

Pipeline Licence

Title	Registered Holder(s)
PL 1 R1	APT PARMELIA PTY LTD
PL 2 R1	APT PARMELIA PTY LTD
PL 3 R1	APT PARMELIA PTY LTD
PL 5 R1	APT PARMELIA PTY LTD
PL 6 R3	AWE PERTH PTY LTD
PL 7 R1	BURU ENERGY LIMITED
PL 8 R1	MITSUI IRON ORE DEVELOPMENT PTY LTD NIPPON STEEL & SUMIKIN RESOURCES AUSTRALIA PTY LTD NIPPON STEEL & SUMITOMO METAL AUSTRALIA PTY LTD NORTH MINING LIMITED ROBE RIVER MINING CO. PTY LTD*
PL 12 R1	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
PL 14 R1	HYDRA ENERGY (WA) PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD TAP (SHELFAL) PTY LTD
PL 15 R1	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
PL 16	DBP DEVELOPMENT GROUP NOMINEES PTY LIMITED
PL 17	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
PL 18	AWE (BEHARRA SPRINGS) PTY LTD ORIGIN ENERGY DEVELOPMENTS PTY LIMITED*
PL 19	DBP DEVELOPMENT GROUP NOMINEES PTY LIMITED
PL 20	DBP DEVELOPMENT GROUP NOMINEES PTY LIMITED
PL 21	CHEVRON (TAPL) PTY LTD CHEVRON AUSTRALIA PTY LTD* MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED SANTOS OFFSHORE PTY LTD
PL 22	APA (PILBARA PIPELINE) PTY LTD
PL 24	ALINTA ENERGY GGT PTY LIMITED SOUTHERN CROSS PIPELINES (NPL) AUSTRALIA PTY LTD SOUTHERN CROSS PIPELINES AUSTRALIA PTY LIMITED*
PL 25	SOUTHERN CROSS PIPELINES AUSTRALIA PTY LIMITED
PL 26	SOUTHERN CROSS PIPELINES AUSTRALIA PTY LIMITED
PL 27	SOUTHERN CROSS PIPELINES AUSTRALIA PTY LIMITED
PL 28	SOUTHERN CROSS PIPELINES (NPL) AUSTRALIA PTY LTD
PL 29	QUADRANT EAST SPAR PTY LIMITED QUADRANT KERSAIL PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD
PL 30	QUADRANT EAST SPAR PTY LIMITED QUADRANT KERSAIL PTY LTD QUADRANT OIL AUSTRALIA PTY LIMITED* SANTOS (BOL) PTY LTD
PL 31	APA (PILBARA PIPELINE) PTY LTD
PL 32	APT PIPELINES (WA) PTY LIMITED
PL 33	APT PIPELINES (WA) PTY LIMITED
PL 34	NORTHERN STAR RESOURCES LTD
PL 35	NORTHERN STAR RESOURCES LTD
PL 36	AUSTRALIAN PIPELINE LIMITED
PL 37	NORILSK NICKEL CAWSE PTY LTD
PL 38	APA (PILBARA PIPELINE) PTY LTD
PL 39	ORIGIN ENERGY PIPELINES PTY LIMITED
PL 40	DBNGP (WA) NOMINEES PTY LIMITED
PL 41	DBNGP (WA) TRANSMISSION PTY LIMITED
PL 42	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT EAST SPAR PTY LIMITED QUADRANT KERSAIL PTY LTD QUADRANT NORTHWEST PTY LTD* QUADRANT OIL AUSTRALIA PTY LIMITED SANTOS (BOL) PTY LTD
PL 43	APT PIPELINES (WA) PTY LIMITED* REGIONAL POWER CORPORATION
PL 44	APT PARMELIA PTY LTD
PL 46	APT PARMELIA PTY LTD
PL 47	DBNGP (WA) TRANSMISSION PTY LIMITED
PL 48	ENERGY GENERATION PTY LTD
PL 52	APT PARMELIA PTY LTD
PL 53	APT PARMELIA PTY LTD
PL 54	APT PIPELINES (WA) PTY LIMITED* REGIONAL POWER CORPORATION
PL 55	WODGINA LITHIUM PTY LTD
PL 56	WODGINA LITHIUM PTY LTD
PL 57	AUSTRALIAN GOLD REAGENTS PTY LTD
PL 58	BHP BILLITON PETROLEUM (NORTH WEST SHELF) PTY LTD BP DEVELOPMENTS AUSTRALIA PTY LTD CHEVRON AUSTRALIA PTY LTD JAPAN AUSTRALIA LNG (MIMI) PTY LTD SHELL AUSTRALIA PTY LTD WOODSIDE ENERGY LTD*
PL 59	ESPERANCE PIPELINE CO. PTY LIMITED
PL 60	EII GAS TRANSMISSION SERVICES WA (OPERATIONS) PTY LIMITED
PL 61	APT PARMELIA PTY LTD
PL 62	HARRIET (ONYX) PTY LTD KUFPEC AUSTRALIA PTY LTD QUADRANT NORTHWEST PTY LTD*
PL 63	EII GAS TRANSMISSION SERVICES WA (OPERATIONS) PTY LIMITED
PL 64	AWE PERTH PTY LTD* ORIGIN ENERGY DEVELOPMENTS PTY LIMITED
PL 65	SARACEN METALS PTY LIMITED
PL 67	HAMERSLEY IRON PTY LIMITED
PL 68	EII GAS TRANSMISSION SERVICES WA (OPERATIONS) PTY LIMITED
PL 69	DBNGP (WA) NOMINEES PTY LIMITED
PL 70	A.C.N. 008 939 080 PTY LTD A.C.N. 008 988 930 PTY LTD ROC OIL (WA) PTY LIMITED*
PL 72	EDL NGD (WA) PTY LTD
PL 73	REDBACK PIPELINES PTY LTD
PL 74	EDL LNG (WA) PTY LTD
PL 75	EIT NEERABUP POWER PTY LTD ERM NEERABUP PTY LTD*
PL 76	SOUTHERN CROSS PIPELINES AUSTRALIA PTY LIMITED

TABLE 5. LIST OF PETROLEUM TITLES AND HOLDERS IN WESTERN AUSTRALIAN JURISDICTIONS AS AT 9 FEBRUARY 2017

PL 77	SINO IRON PTY LTD	PL 94	DBNGP (WA) NOMINEES PTY LIMITED
PL 78	HAMERSLEY IRON PTY LIMITED	PL 95	DBNGP (WA) NOMINEES PTY LIMITED
PL 80	ALCOA OF AUSTRALIA LIMITED LATENT PETROLEUM PTY LTD*	PL 96	EMPIRE OIL COMPANY (WA) LIMITED
PL 81	QUADRANT NORTHWEST PTY LTD SANTOS OFFSHORE PTY LTD	PL 97	MITSUI IRON ORE DEVELOPMENT PTY LTD NIPPON STEEL & SUMIKIN RESOURCES AUSTRALIA PTY LTD NIPPON STEEL & SUMITOMO METAL AUSTRALIA PTY LTD NORTH MINING LIMITED ROBE RIVER MINING CO. PTY LTD*
PL 82	APA (PILBARA PIPELINE) PTY LTD	PL 98	ESPERANCE PIPELINE CO. PTY LIMITED
PL 83	ATCO GAS AUSTRALIA PTY LTD	PL 99	CHEVRON (TAPL) PTY LTD* KUFPEC AUSTRALIA (JULIMAR) PTY LTD KYUSHU ELECTRIC WHEATSTONE PTY LTD PE WHEATSTONE PTY LTD SHELL AUSTRALIA PTY LTD WOODSIDE ENERGY JULIMAR PTY LTD
PL 84	CHEVRON (TAPL) PTY LTD* JERA GORGON PTY LTD MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED OSAKA GAS GORGON PTY LTD SHELL AUSTRALIA PTY LTD TOKYO GAS GORGON PTY LTD	PL 100	DBNGP (WA) NOMINEES PTY LIMITED
PL 85	CHEVRON (TAPL) PTY LTD* JERA GORGON PTY LTD MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED OSAKA GAS GORGON PTY LTD SHELL AUSTRALIA PTY LTD TOKYO GAS GORGON PTY LTD	PL 101	DBNGP (WA) NOMINEES PTY LIMITED
PL 86	QUADRANT NORTHWEST PTY LTD* SANTOS OFFSHORE PTY LTD	PL 102	SUB161 PTY LTD
PL 87	BHP BILLITON PETROLEUM (AUSTRALIA) PTY LTD* QUADRANT PVG PTY LTD	PL 103	DBP DEVELOPMENT GROUP NOMINEES PTY LIMITED
PL 88	BHP BILLITON PETROLEUM (AUSTRALIA) PTY LTD* QUADRANT PVG PTY LTD	PL 104	APA (PILBARA PIPELINE) PTY LTD
PL 89	CROSSLANDS RESOURCES PTY LTD	PL 105	DDG FORTESCUE RIVER PTY LTD* TEC PILBARA PTY LTD
PL 90	BHP BILLITON PETROLEUM (AUSTRALIA) PTY LTD* QUADRANT PVG PTY LTD	PL 106	MITSUI IRON ORE DEVELOPMENT PTY LTD NIPPON STEEL & SUMIKIN RESOURCES AUSTRALIA PTY LTD NIPPON STEEL & SUMITOMO METAL AUSTRALIA PTY LTD NORTH MINING LIMITED ROBE RIVER MINING CO. PTY LTD*
PL 91	DBNGP (WA) NOMINEES PTY LIMITED	PL 108	APA OPERATIONS PTY LIMITED
PL 92	CHEVRON (TAPL) PTY LTD* JERA GORGON PTY LTD MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED OSAKA GAS AUSTRALIA PTY LTD SHELL AUSTRALIA PTY LTD TOKYO GAS GORGON PTY LTD	PL 109	BURU ENERGY LIMITED
PL 93	CHEVRON (TAPL) PTY LTD* JERA GORGON PTY LTD MOBIL AUSTRALIA RESOURCES COMPANY PTY LIMITED OSAKA GAS GORGON PTY LTD SHELL AUSTRALIA PTY LTD TOKYO GAS GORGON PTY LTD	PL 110	DDG ASHBURTON PTY LTD*
		PL 111	AWE PERTH PTY LTD* ORIGIN ENERGY DEVELOPMENTS PTY LIMITED
		PL 112	DBP DEVELOPMENT GROUP NOMINEES PTY LIMITED

* denotes Nominee

Please consult DMP's online Petroleum and Geothermal Register for the most current information on Titles and Holdings.

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Department of **Mines and Petroleum**