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PROSPECTIVITY OF STATE ACREAGE RELEASE AREA L07-1, FITZROY TROUGH AND LENNARD SHELF, CANNING BASIN

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Introduction

The Canning Basin of northern Western Australia is a large predominantly onshore sedimentary basin covering about 595 000 km^2 (Fig. 1). It preserves a long and complex multi-phase depositional history extending from the Early Ordovician to the Cretaceous (Fig. 2), and while containing several small producing oilfields, is currently under-explored for petroleum resources. Overviews of basin geology and hydrocarbon systems may be found in Kennard et al. (1994) and Carlsen and Ghori (2005). The Canning Basin is subdivided into a series of troughs, sub-basins, platforms, shelves, and terraces bounded by generally northwest–southeast trending syn-depositional fault systems (Fig. 1). Release area L07-1 (5062 km^2) is situated mainly in the Fitzroy Trough, but locally extends onto the southern edge of the adjacent Lennard Shelf and Pender Terrace (Fig. 3). The western end of L07-1 extends across southern King Sound. Outcrop of Canning Basin strata in the release area is very limited, and mainly of Mesozoic age. The coastal port town of Derby is situated within L07-1, with access to the area afforded via the sealed Great Northern Highway and a number of secondary community and homestead roads and tracks. An oil pipeline connects the Blina oilfield to a loading facility on this highway just east of the release area.

Regional geology and stratigraphy

The Fitzroy Trough contains the thickest sedimentary fill within the Canning Basin, locally inferred to reach ~15 km. The most active period of fault movement and subsidence was during the Devonian–Carboniferous. The deepest wells in the Fitzroy Trough have intersected thick marine Devonian to Early Carboniferous strata, overlain by shallow marine to deltaic Carboniferous Anderson Formation. Regional unconformities separate this part of the succession from the mostly non-marine Reeves Formation and Grant Group of Late Carboniferous – Early Permian age, the latter being partly glacigenic in origin. Further phases of marine and fluvial sedimentation took place in the latter part of the Permian to Early Triassic and during the Jurassic–Cretaceous. The deeper stratigraphy of the Fitzroy Trough is poorly known, being beyond penetration by exploration wells, but it is assumed to include older Devonian strata and equivalents of the Ordovician to Silurian shallow marine and overlying salt-bearing successions that are widespread elsewhere in the Canning Basin.

To the north of the Fitzroy Trough the Lennard Shelf contains up to about 4 km of mainly Devonian and younger strata. The outer (southern) Lennard Shelf, sometimes referred to as the Laurel Downs Terrace, is slightly thicker than the main part of the shelf to the north, and is structurally controlled by a complex series of northwest-trending fault systems and northeast-trending transfer zones (Crostella, 1998). A

similar situation probably exists on the Pender Terrace in the northwest corner of L07-1, although data are sparse. In the Middle to Late Devonian, extension and subsidence led to marine flooding of the Lennard Shelf and Pender Terrace, during which a complex of carbonate reefs formed on fault-controlled structural highs flanked by fine-grained basinal facies. The reef complexes are overlain by latest Devonian to Early Carboniferous shallow-marine carbonate and fine clastic rocks of the Fairfield Group, and interbedded sandstone and mudstone of the deltaic to fluvial Early Carboniferous Anderson Formation. An angular unconformity separates the Anderson Formation from latest Carboniferous to Early Permian mostly non-marine and partly glacigenic clastics of the Grant Group, overlain in turn by shallow marine grading to fluvio-deltaic sedimentary rocks of Early to Late Permian age (Poole Sandstone, Noonkanbah Formation, and Liveringa Group). A final marine transgression in the Early Triassic led to deposition of muds (Blina Shale), followed locally by fluvial sand (Erskine Sandstone).

Petroleum prospectivity

Petroleum exploration wells previously drilled in L07-1, along with selected wells from closely adjacent areas, are detailed in Table 1. Available seismic data are indicated on Figure 3. Seismic data are mainly restricted to southern and northern parts of the release area, with a large area in the centre devoid of data.

Lennard Shelf

The Lennard Shelf has had a long history of oil exploration and consequently its petroleum systems are better understood than those of the Fitzroy Trough. The 1919 report of an oil show in a water bore on the Lennard Shelf led to the drilling of several exploratory wells by the Freney Kimberley Oil Company between 1922 and 1941. West Australian Petroleum (WAPET) began exploration in the area in the 1950s, proving beyond doubt the existence of a petroleum system for the first time. The modern phase of petroleum exploration began in the 1970s with the first commercial discovery, Blina 1, made by Home Energy in 1981. This led to the drilling of seven additional wells in the Blina oilfield, and the subsequent discovery of the Lloyd, Boundary, West Terrace, and Sundown oilfields, all lying in a northwest-trending belt immediately east of L07-1, and West Kora 1 oil and Point Torment 1 gas discoveries, lying to the north of L07-1 (Crostella, 1998; Jonasson, 2001).

Geochemical data point to the presence of two main regional source rock units in this area, namely the Middle–Upper Devonian Gogo Formation, a basinal shaly unit deposited adjacent to and contemporaneously with the reefs, and the Lower Carboniferous shallow-marine Laurel Formation of the Fairfield Group. In the majority of cases, oils can be typed to the latter, but no exhaustive characterization has been carried out (Crostella, 1998). Within the Lennard Shelf, the Laurel Formation is mostly immature, whereas the deeper Gogo Formation has reached maturity over wider areas. However, long distance migration from sites of deeper burial in the adjacent Fitzroy Trough, mainly via the northeast-trending transfer fault zones, is considered a likely scenario relating to the known Lennard Shelf oil accumulations

(Crostella, 1998). These faults include the Meda, Sundown, Blackstone, and Mount Percy Transfer Zones (see Middleton, 1991; Crostella, 1998). Although not demonstrated, the possibility of lateral migration of Ordovician-sourced oils into Lennard Shelf traps should also be considered.

Known oil accumulations are reservoired in a number of different stratigraphic units ranging from Late Devonian to Early Permian in age (Fig. 4). At Blina, the largest oilfield, oil has mainly accumulated in fracture porosity within Upper Devonian reef carbonates, with smaller reserves in dolomites in the overlying Fairfield Group. A number of other wells have oil shows in these settings. Fracturing is probably related to the mid-Late Carboniferous Meda transpressional event (Crostella, 1998). Younger reservoirs are mainly in clastic rocks and include sandstone horizons in the Anderson Formation (Lloyd oilfield, West Kora 1 oil well, Point Torment 1 gas well), and sandstone in the basal Grant Group (Sundown, West Terrace, and Boundary oilfields). Shales within the Fairfield Group, Anderson Formation, and Grant Group provide adequate seals, respectively, but effective seals are unlikely above the middle of the Grant Group (Crostella, 1998). Traps identified to date include fault-controlled anticlines and flower structures, and gentle drape closures over reef structures. Classic Lennard Shelf-style oil and gas plays are possible in local parts of L07-1 that overlap the Lennard Shelf and Pender Terrace.

Fitzroy Trough

The Fitzroy Trough has long been considered one of the most prospective parts of the Canning Basin because of its substantial sedimentary section, carbonate buildup/reefal developments along the half-graben hingeline in the north, and structural development in the southwest (Jonasson, 2001). Despite an early start to exploration of the trough by Freney Kimberley Oil Company in 1922, the discoveries of oil on the Lennard Shelf in the 1980s have focused most modern exploration further north. Only four wells have been drilled within the Fitzroy Trough in L07-1 (Booran 1, East Yeeda 1, Millard 1, and Puratte 1) and, although the results have been disappointing, the area must be considered very under-explored.

Similar petroleum systems to those demonstrated on the Lennard Shelf are possible in the Fitzroy Trough. The distribution of Devonian and Carboniferous facies in the Fitzroy Trough is less well known due to the limited number of well intersections, and no wells have penetrated the complete Devonian section. Thick black shales are present in the lower Fairfield Group in some wells, although a detailed study of source rock potential has not been undertaken in the area. Based on regional observations, source rocks may be expected in the Devonian section as well as the Carboniferous Laurel and Anderson Formations, and the Lower Permian Grant Group; the latter is expected to be gas prone. Due to burial depth, some source units are now likely to be overmature throughout much of the Fitzroy Trough, except perhaps near the margins. Ellyard (1984) calculated that peak generation and migration of oil from equivalents of the Upper Devonian Pillara Formation and Lower Carboniferous Laurel Formation occurred in the Paleozoic and Mesozoic, respectively, in most areas of the Fitzroy Trough. Sandstone horizons in the Laurel, Anderson, and Reeves Formations, the Grant Group, and various Mesozoic units all have the potential to act as reservoirs,

depending on burial depths and the presence of overlying seals. Devonian carbonate reservoirs may also be present.

Of the Fitzroy Trough wells, the best hydrocarbon shows were gas flows in carbonates of the Laurel Formation in St Georges Range 1 (2.9 Mm^3/day), and sandstones of the Anderson Formation in Yulleroo 1 (336 m^3/day); a Laurel Formation source is inferred in each case (Cadman et al., 1993). These wells are about 140 km southeast and 80 km southwest of L07-1, respectively. Significant oil shows have also been reported from other Fitzroy Trough wells. These shows demonstrate that hydrocarbons have been generated and migrated within the Fitzroy Trough, and it has been hypothesized that at least some Lennard Shelf oils have been sourced within the Fitzroy Trough (Ellyard, 1984; Crostella, 1998).

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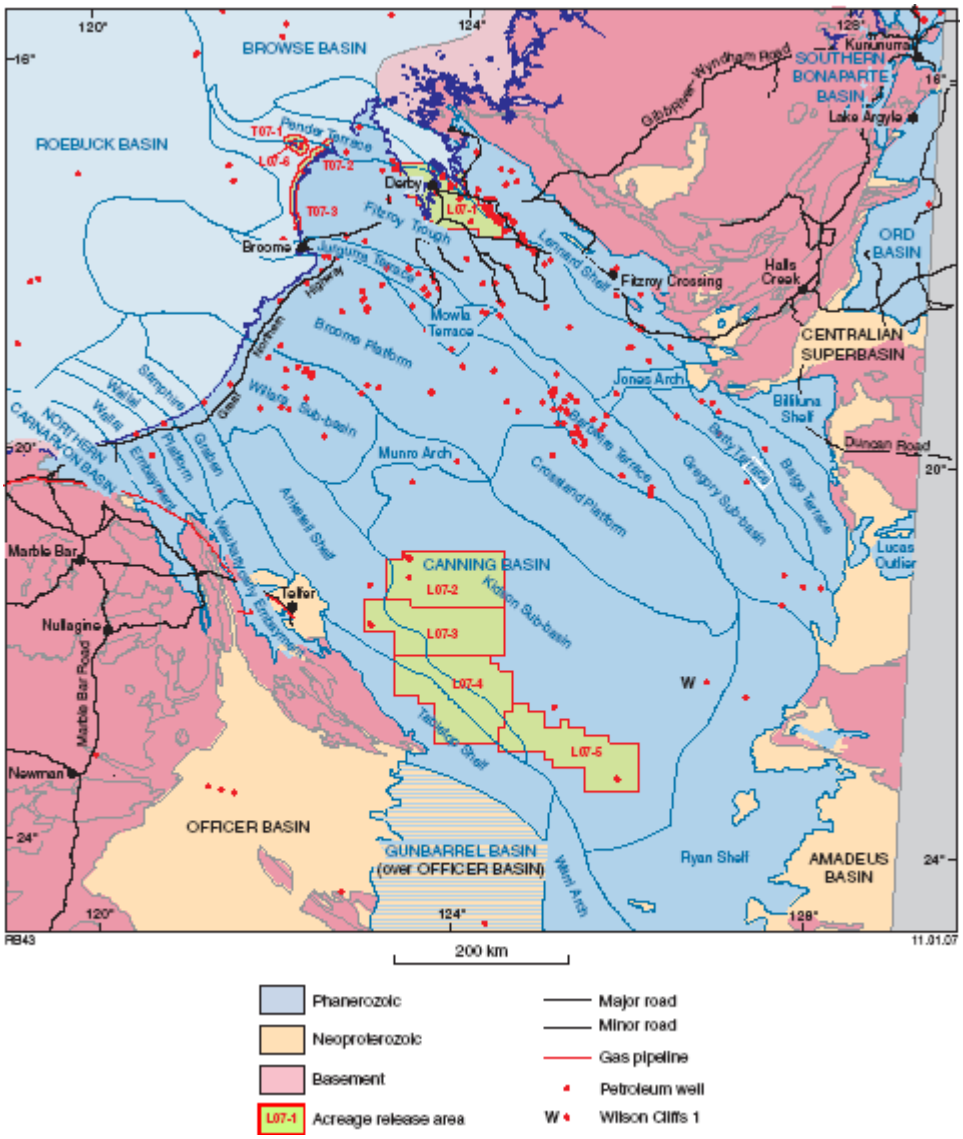

Figure 1. The Canning Basin showing major basin subdivisions and location of April 2007 Acreage Release Areas

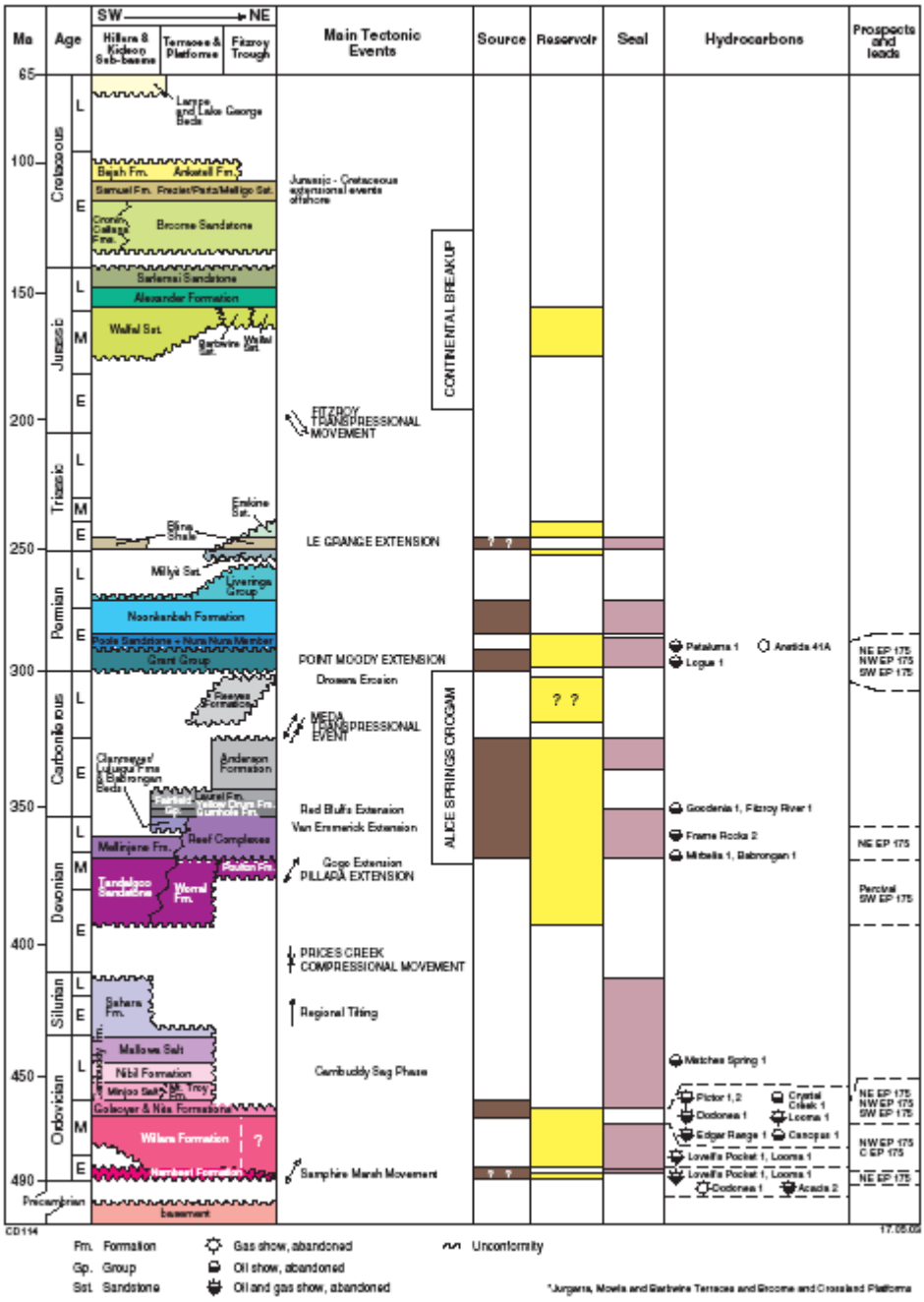

Figure 2. Generalized stratigraphy of the Canning Basin with major petroleum elements and occurrences indicated (modified after D'Ercole et al., 2003)

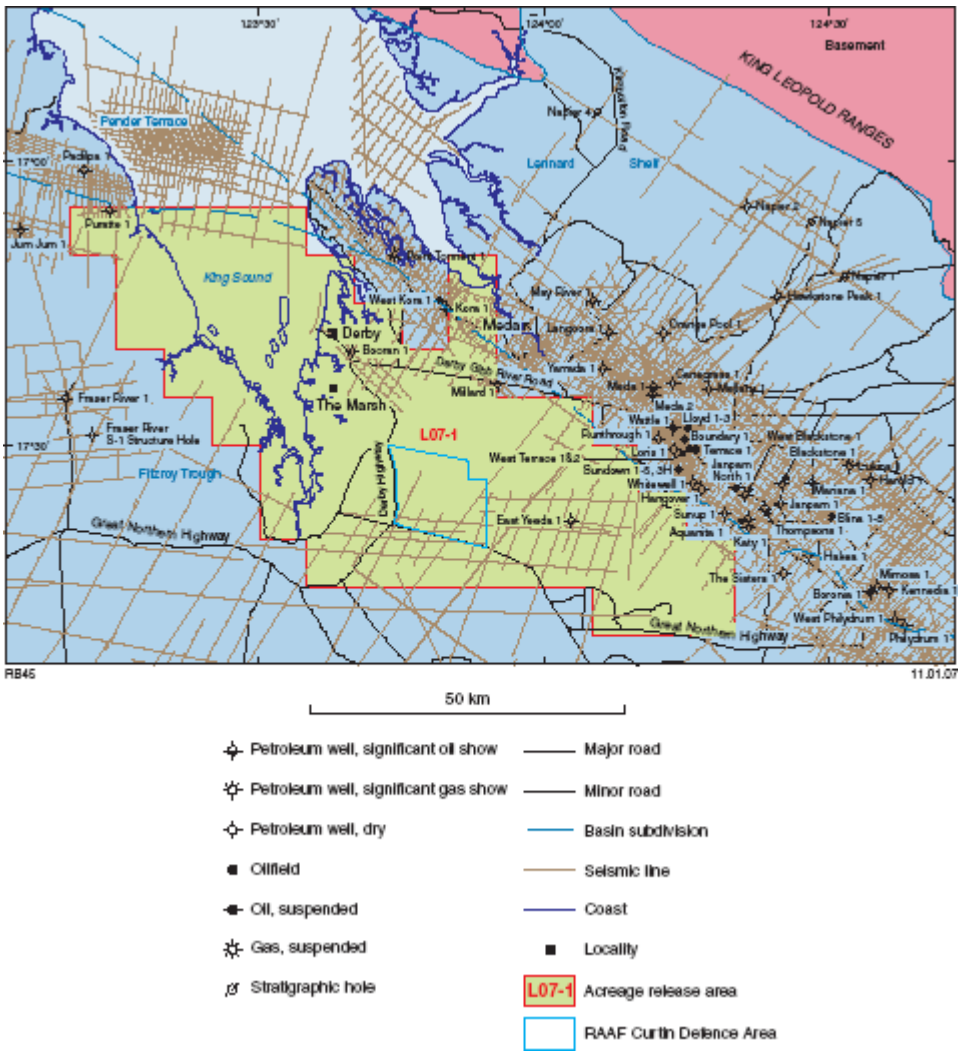

Figure 3. Location, seismic data and wells drilled in L07-1

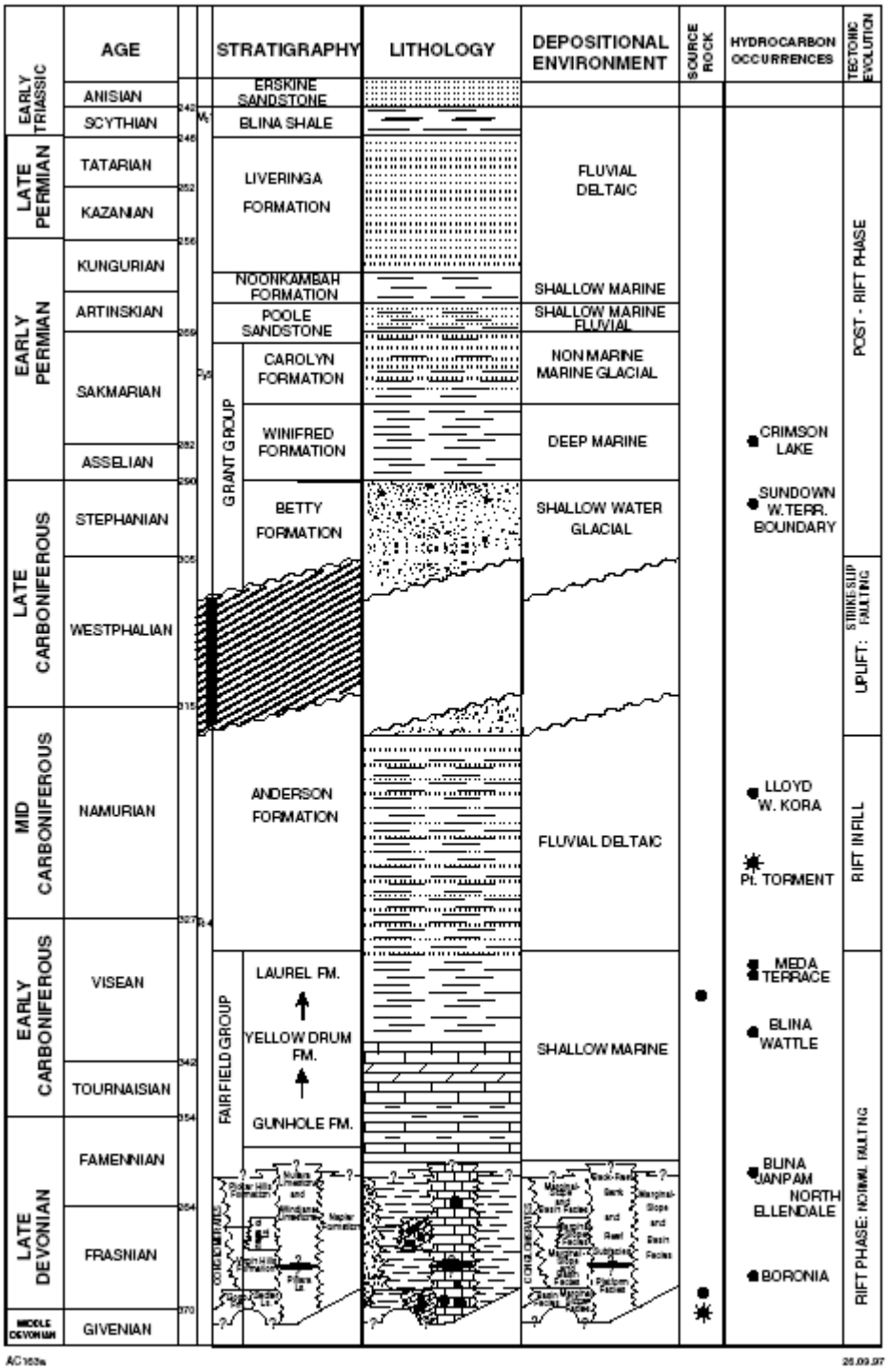

Figure 4. Devonian to Triassic stratigraphy and petroleum occurrences of the Lennard Shelf (after Crostella, 1998)

Table 1. Petroleum exploration wells within, and selected wells adjacent to, L07-1

Well	*Latitude*	*Longitude*	*Operator*	*Year*	*Class*	*Status*	*TD (m)*	*Elevation (m)*	*TD age*	*Oil shows*[(a)]	*Gas shows*[(a)]
Blina 1	17°37'21"	124°30'06"	Home Energy	1981	NFW	O	2 498	57	Devonian	Producer	Poor (MG)
Booran 1	17°20'03"	123°39'53"	Esso	1982	NFW	P&A	2 800	18	Permian	Poor (F)	Poor (MG)
Boundary 1	17°29'09"	124°14'43"	Petsec	1990	NFW	SUSP O	1 670	39	Carboniferous	Producer	Nil
East Yeeda 1	17°37'54"	124°02'55"	Bridge Oil	1985	NFW	P&A	3 556	92	Devonian	Poor (F)	Poor (MG)
Fraser River 1	17°25'03"	123°09'44"	WAPET	1955–6	NFW	P&A	3 092	53	Carboniferous	Nil	Nil
Fraser River S 1	17°28'50"	123°12'30"	WAPET	1955	STR	P&A	366	43	–	Nil	Nil
Jum Jum 1	17°07'16"	123°05'02"	Esso	1985	NFW	P&A	2 600	89	Carboniferous	Poor (F)	Nil
Kora 1	17°15'33"	123°49'47"	Esso	1982	NFW	P&A OS	3 100	9	Devonian	Excellent (O,F)	Poor (MG)
Lloyd 1	17°27'58"	124°15'01"	Home Energy	1987	NFW	O	2 001	39	Devonian	Producer	Poor (MG)
Millard 1	17°23'32"	123°55'10"	Capital Energy	1997	NFW	P&A	1 680	50	Permian	Nil	Nil
Padilpa 1	17°00'58"	123°11'39"	Sydney Oil	1987	NFW	P&A	2 184	44	Carboniferous	Nil	Poor (MG)
Point Torment 1	17°09'53"	123°44'20"	Anzoil	1992	NFW	G	2 130	9	Devonian	Good	Producer
Point Torment 1 Deepening	17°09'53"	123°44'20"	Stirling Resources	1994	NFW	G	2 604	9	Devonian	Poor	Excellent
Puratte 1	17°05'11"	123°14'22"	Esso	1979–80	NFW	P&A	3 750	27	Devonian	Poor (F)	Poor (MG)
Sundown 1	17°33'05"	124°14'35"	Home Energy	1982	NFW	SUSP O	2 736	39	Devonian	Producer	Nil
Sunup 1	17°37'08"	124°19'02"	Home Energy	1985	NFW	P&A	1 500	58	Permian	Nil	Nil
The Sisters 1	17°43'26"	124°25'14"	AFO	1956–7	NFW	P&A	2 996	90	Devonian	Poor (B)	Nil
West Kora 1	17°14'43"	123°49'05"	Esso	1984	NFW	SUSP O	2 606	9	Devonian	Excellent (O)	Poor (MG)
West Terrace 1	17°30'21"	124°15'36"	Home Energy	1985	NFW	O	1 250	32	Carboniferous	Producer	Nil

NOTES: (a) Shows summarized from well completion reports (O: oil, B: bitumen, F: fluorescence, MG: mud gas show, MF: measured gas flow)

TD	Total depth	SUSP	Suspended	AFO	Associated Freney Oilfields
NFW	New field wildcat	O	Oil well	Esso	Esso Exploration & Production
STR	Stratigraphic hole	G	Gas well	Petsec	Petroleum Securities Energy
P&A	Plugged and abandoned	OS	Oil show	WAPET	West Australian Petroleum Pty Ltd

SOURCE: Data extracted from DoIR's WA Petroleum Information Management System (WAPIMS) and well completion reports