Proposed Browse to NWS Development, EPBC Act and EP Act Environmental Referrals

Supporting Document

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TABLE OF CONTENTS

1. INTRODUCTION 6
1.1 Overview of Proposed Action 6
1.2 Project History 6
1.2.1 Initial Concept Select 6
1.2.2 James Price Point Concept 7
1.2.3 FLNG Concept 7
1.2.4 Browse to North West Shelf Concept 7
1.3 Comparison with Browse FLNG Concept 7
1.4 Purpose and Scope of this Document 8
1.4.1 Purpose 8
1.4.2 Scope 9
1.5 Legislative Framework 10
1.5.1 Applicable Commonwealth Legislation and Policies 10
1.5.2 Applicable State Legislation 11
2. DETAILED DESCRIPTION OF PROPOSED ACTION 12
2.1 Development Overview 12
2.1.1 Project Area 12
2.1.2 Key Characteristics - Overall Development 14
2.1.3 Development within State Waters 16
2.2 Development Schedule 21
2.3 Infrastructure 21
2.3.1 Wells 21
2.3.2 Subsea Infrastructure and Flexible Risers 21
2.3.3 FPSO Facilities 22
2.3.4 BTL and Inter-Field Spur Line 22
2.3.5 NWS Second Trunkline 22
2.4 Development Activities 23
2.4.1 Development Drilling 23
2.4.1.1 Drilling Method 23
2.4.1.2 Drilling Fluids 23
2.4.1.3 Drilling and Completions Unplanned Contingent Activities 24
2.4.2 Subsea Umbilicals, Risers and Flowlines (SURF) 24
2.4.2.1 Site Preparation 24
2.4.2.2 Installation of Subsea Infrastructure 24
2.4.2.3 Installation of Flexible Risers 25
2.4.3 Installation of FPSO Facilities 25
2.4.4 Installation of BTL and Inter-Field Spur Line 25
2.4.5 Commissioning 25
2.5 Operations 26
2.5.1 Hydrocarbon Extraction 26
2.5.2 Processing 26

2.5.3 Condensate offload 26
2.5.4 Gas Export 26
2.6 Decommissioning 26
2.7 Support Activities and Infrastructure 27
2.7.1 Support Vessels and Helicopters 27
2.7.2 Communications 27
2.7.3 Supply Chain and Logistics Support 27
2.8 Anticipated Discharges and Emissions 27
2.8.1 Overview 27
2.8.2 Atmospheric and Greenhouse Emissions 29
2.8.3 Liquid Discharges 30
2.8.3.1 Hydrotest Fluid 30
2.8.3.2 Produced Water 30
2.8.3.3 Cooling Water 31
2.8.3.4 Subsea Control Fluids 32
2.8.3.5 Desalination Brine 32
2.8.3.6 Drain Discharges 32
2.8.3.7 Sewage and Sullage 32
2.8.4 Drill Cuttings and Fluids 33
2.8.5 Solid Waste 34
2.8.5.1 Non Hazardous Solid Waste 34
2.8.5.2 Putrescible 34
2.8.5.3 Hazardous Waste 34
2.8.6 Other Emission Sources 34
2.8.6.1 Ballast Water and Biofouling 34
2.8.6.2 Noise Emissions 35
2.8.6.3 Artificial Light Emissions 37
3. STAKEHOLDER CONSULTATION 38
4. STUDIES AND INFORMATION SOURCES 39
4.1 Overview 39
4.2 Completed Studies 39
4.3 Current and Planned Studies 39
5. EXISTING ENVIRONMENT 41
5.1 Introduction 41
5.2 Regional Characteristics 41
5.2.1 Marine Region 41
5.2.2 Oceanographic Environment and Coastal Processes 42
5.2.3 Sediment 42
5.2.4 Water Quality 42
5.2.5 Air Quality 45
5.2.6 Light 45

5.2.7 Underwater Noise 45
5.2.8 Submerged and Emergent Reefs and Shoals 45
5.2.8.1 Scott Reef 45
5.2.8.2 Rowley Shoals 45
5.2.8.3 Seringapatam Reef 46
5.2.8.4 Rankin Bank 46
5.2.8.5 Glomar Shoals 46
5.3 Ecological Communities 47
5.3.1 Planktonic Communities 47
5.3.2 Benthic Communities and Benthic Primary Producers 47
5.3.2.1 Browse Development Area 47
5.3.2.2 BTL and Inter-Field Spur Line Corridor 51
5.3.3 Listed Threatened Ecological Communities 51
5.4 Fauna 51
5.4.1 Protected Species 51
5.4.2 Biologically Important Areas 53
5.4.3 Seabirds and Migratory Shorebirds 57
5.4.3.1 Seabirds 57
5.4.3.2 Migratory Shorebirds 58
5.4.4 Marine Mammals 58
5.4.5 Fish 64
5.4.6 Marine Reptiles 64
5.4.6.1 Marine Turtles 64
5.4.6.2 Sea Snakes 67
5.5 Key Ecological Features 67
5.6 Protected Places 70
5.6.1 World Heritage Properties 70
5.6.2 National Heritage Places 70
5.6.3 Commonwealth Heritage List 70
5.6.4 Australian Marine Parks 71
5.6.5 State Marine Parks and Reserved Land 75
5.6.6 Ramsar Wetlands of International Importance 75
5.6.7 Nationally Important Wetlands 75
5.7 Socio-Economic and Cultural 75
5.7.1 Heritage Values 75
5.7.1.1 Indigenous Heritage 75
5.7.1.2 Marine Archaeology 75
5.7.2 Fisheries 76
5.7.2.1 Commonwealth and State Managed Fisheries 76
5.7.2.2 Aquaculture 77

5.7.2.3 Traditional Fisheries 77
5.7.3 Other Users 77
5.7.3.1 Scientific Research 77
5.7.3.2 Tourism 77
5.7.3.3 Shipping 78
5.7.3.4 Industry 78
6. NATURE AND EXTENT OF LIKELY IMPACTS 79
6.1 Impact Assessment Approach 79
6.2 Environmental Impact Assessment 79
6.3 Environmental Risk Assessment 85
7. MEASURES TO AVOID OR REDUCE IMPACTS 89
8. SUMMARY OF ASSESSMENT AGAINST EPBC ACT SIGNIFICANT IMPACTS CRITERIA 94
9. SUMMARY OF ASSESSMENT AGAINST WA EPA OBJECTIVES 110
10. REFERENCES 122
APPENDIX A – Studies undertaken to support the development of the Browse resource 130
APPENDIX B - Summary of Potential Presence of EPBC Listed Threatened and / or Migratory Species 133
APPENDIX C – Protected Matters Search Tool Report 141

1. Introduction

1.1 Overview of Proposed Action

The Browse hydrocarbon resource is located in the Brecknock, Calliance and Torosa reservoirs located approximately 425 km north of Broome and approximately 290 km off the Kimberley coastline. The Browse Joint Venture (BJV) holds seven petroleum retention leases under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act), the WA *Petroleum (Submerged Lands) Act 1982* (PSL Act) and the *Petroleum and Geothermal Energy Resources Act 1967* (WA). Five of the leases (WA-28-R, WA-29-R, WA-30-R, WA-31-R and WA-32-R) are located in Commonwealth waters. Two leases (TR/5 and R2) are within the State of Western Australia's (State) jurisdiction.

The Brecknock, Calliance and Torosa reservoirs were discovered between 1971 and 2000. Hydrocarbon resources contained in these reservoirs are predominately gas, with contingent resources (2C, 100%) of 13.9 trillion cubic feet (tcf) of dry gas, and approximately 390 million barrels of condensate (Woodside estimate).

Woodside Energy Ltd (Woodside) is Operator for and on behalf of the BJV (Woodside Browse Pty Ltd, Shell Australia Pty Ltd (Shell), BP Developments Australia Pty Ltd (BP), Japan Australia LNG (MIMI Browse) Pty Ltd (MIMI) and PetroChina International Investment (Australia) Pty Ltd (PetroChina)).

The BJV propose to develop the Browse resource using two Floating Production Storage and Offloading (FPSO) facilities with up to 1100 Million standard cubic feet per day (MMscfd) export capacity (annual daily average). The FPSOs will be supplied by a subsea production system and will export gas to existing North West Shelf (NWS) Project infrastructure via a ~85 km spur line and a ~900 km proposed Browse Trunkline (BTL) which will tie in near the North Rankin Complex (NRC).

Construction is expected to commence approximately 2021-2022, with operations expected for up to 50 years.

1.2 Project History

1.2.1 Initial Concept Select

Woodside has conducted multiple 'Concept Select' phases for the commercialisation of the Browse reservoirs. The following five potential development concepts have been considered since 2004:

- Piping Browse gas to the Kimberley for processing onshore (James Price Point (JPP) development concept)
- Piping Browse gas to the Burrup Peninsula for processing onshore
- Piping Browse gas to Darwin for processing onshore
- Offshore Liquefied Natural Gas (LNG), where processing would take place on a platform at Scott Reef
- Floating LNG (FLNG), where processing would take place on a floating facility.

Selection of the concept for the development of the Browse resources considered the following:

- Technical, financial and volumes analysis
- Environmental, social and economic (ESE) evaluation
- Stakeholder engagement.

1.2.2 James Price Point Concept

The BJV selected the JPP development concept in 2010 and progressed both State and Commonwealth environmental approvals (upstream: EPBC 2008/4111, downstream: referral and request that the proposal be declared a derived proposal under Ministerial Statement 917). In April 2013, Woodside announced that the JPP development concept did not meet the company's commercial requirements for a positive Final Investment Decision (FID).

1.2.3 FLNG Concept

Following the JPP development concept decision, Woodside undertook a review of the concepts. Based on advances made in the FLNG technology and business confidence, Woodside announced that the BJV had selected FLNG technology as the development concept to progress the commercialisation of the Browse resource.

In November 2013, the FLNG development concept was referred under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC 2013/7079). The portion of the development concept that lies in State waters (the Torosa Subsea Development) was also referred to the State Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* (EP Act) in December 2014. The FLNG development concept received approval under the EPBC Act in August 2015. The WA EPA made a decision that the Torosa Subsea Development did not require assessment under the EP Act in February 2015. In March 2016, Woodside announced that following completion of front-end engineering and design (FEED) work, the BJV had decided not to progress with the FLNG development concept at the time considering the prevailing economic and market environment.

1.2.4 Browse to North West Shelf Concept

Over a 7-month period between September 2016 and April 2017, the BJV completed a development concept narrowing process with the aim of having 'line of sight to at least one globally competitive and investable development concept which all stakeholders can support'.

Since April 2017, this development concept has been progressed through the Concept Select phase. Engineering and technical studies appropriate for the Concept Select phase have confirmed the preliminary feasibility of the Browse to NWS development concept. The BJV selected a single development concept to be progressed, the Browse to NWS development concept (2 x FPSOs tied back to the NWS via a 42" Browse Trunkline (BTL)). Optimisation studies and other assessments are ongoing, which may result in changes being made to the reference case.

The proposed Browse to NWS development concept (henceforth referred to as the 'Proposed Action'), is the subject of this supporting document (SD) and the associated Commonwealth EPBC Act and State EP Act referrals.

1.3 Comparison with Browse FLNG Concept

While significant similarities exist between the Browse to NWS development concept and the FLNG development concept (as well as the previous JPP development concept), particularly in relation to the subsea infrastructure and floating facilities, the decision has been made to refer the proposed Browse to NWS development as a new action for assessment under the EPBC Act.

In addition, the relevant State waters components of the Browse to NWS development concept, while similar to that referred to the WA EPA in 2015 as the Torosa Subsea Development Proposal (Not Assessed: Public Advice Given), is also being referred to the WA EPA under the State EP Act.

It should be noted however, that due to these similarities, significant work has previously been undertaken with respect to understanding, assessing and mitigating potential environmental impacts and risk.

Similarities between the concepts include the number and locations of wells and subsea tiebacks which have either reduced or remain broadly unchanged from those presented for the FLNG development concept. The notable differences are the addition of the inter-field spur line and the BTL.

With respect to the environmental aspects, the proposed Browse to NWS development concept is expected to lead to the following when compared to the approved FLNG development concept:

- A reduction in the number of offshore facilities (2 x FPSO vs 3 x FLNG). Only one FPSO will be located at Torosa (compared to 2 x FLNG)
- A reduction in the number of development wells from 64 over Development life to a maximum of 49
- A reduction in shipping near Scott Reef as there is no LNG offtake
- A reduction in cooling water discharge
- Approximately the same amount of condensate storage per FPSO and offtake (reduction overall due to 2 x FPSO vs 3 x FLNG)
- The same produced water (PW) discharge design capacity at RFSU. Potential to expand PW design capacity during later field life
- Approximately the same distance between the facilities and Scott Reef
- A reduction in noise sources (fewer offshore facilities and less well drilling, completion and well unload (drilling and completion) activities)
- A reduction in mono ethylene glycol (MEG) injection requirements relating to a change from continuous MEG injection to active heating (noting that MEG injection will still be required for start-up and shutdown)
- A change to MEG discharge within the FPSO PW stream as opposed to recovery on a FLNG facility. This will result in higher MEG concentrations discharged but only at flowline or well restarts as opposed to continuous trace MEG concentrations in the PW stream
- Decreased energy consumption (CO_2) for offshore processing as compared to FLNG based on removal of liquefaction requirements from the proposed offshore development concept. This decrease is partially offset by additional requirement for export compression
- Increased seabed disturbance due to installation of the BTL and the inter-field spur line.

1.4 Purpose and Scope of this Document

1.4.1 Purpose

This document has been prepared as part of the referral of the Proposed Action under the EPBC Act and the EP Act, as the proposed development spans Commonwealth and State jurisdictions. Its purpose is to present an initial environmental impact assessment (EIA) of the Proposed Action and other information as relevant under the EPBC and EP Acts; to assist the Commonwealth Minister for the Environment and the WA EPA in determining whether the Proposed Action requires assessment and approval under the relevant Acts and the level of assessment that will be applied.

This document should be read in conjunction with the EPBC Referral Form and EP Act Referral Form prepared for the Proposed Action.

1.4.2 Scope

For the purpose of the referral under the EPBC Act, the scope of the Proposed Action is limited to construction and operation of the upstream component of the proposed Browse to NWS development concept including:

- Development drilling, completion and well unload activities (drilling and completion) of the Brecknock, Calliance and Torosa reservoirs
- Installation and commissioning of subsea infrastructure, including anchors and mooring lines, umbilicals, flowlines, risers, and manifolds
- Installation and commissioning of the BTL and inter-field spur line including tie-in to existing NWS Project infrastructure near NRC
- Installation, hook-up and commissioning of the FPSOs
- Operation of the subsea infrastructure, including wells/wellheads, umbilicals, flowlines, risers, and manifolds
- Operation of the FPSOs, including condensate stabilisation, storage and offtake, gas processing (CO_2 and water removal and gas compression) and export
- Transmission of gas from the FPSOs to the NWS Project infrastructure tie in point
- Decommissioning of subsea infrastructure, BTL, inter-field spur line and FPSOs at the end of reservoir field life (approximately 50 years).

The transportation and processing of Browse resources from the tie in point near NRC will be undertaken via the use of existing North West Shelf facilities which are the subject of different joint venture arrangements and as such, has not been considered as part of the scope of the referrals. Any required approvals associated with these activities will be progressed separately.

The BJV understand North West Shelf Joint Venture (NWS JV) is preparing to refer a proposal which includes long term processing of third party gas (including Browse) at the Karratha Gas Plant (KGP). Potential impacts associated with the NWS JV action will be described in that referral.

A range of resource appraisal activities and feasibility studies are proposed to support the consideration of a potential development of the Browse gas reservoirs. These activities will include seismic surveys, drilling of appraisal wells (nominally two wells), geophysical, geotechnical and environment surveys. All are short-term and small scale in nature and are not directly related to the development of facilities for the recovery of hydrocarbons from the reservoirs. As such, these activities do not form part of the scope of the Proposed Action. These activities will be subject to separate environmental approvals, as required.

The Proposed Action will involve vessel and helicopter movements in order to support the offshore facilities; however, it is not dependent on the development of new onshore infrastructure in order to proceed.

As the location(s) for supply chain and logistics support infrastructure are not yet determined, vessel and helicopter movements to and from a range of potential locations have been considered. This is consistent with the previously approved action. This is focused on utilising existing infrastructure and related services. These locations are not part of the scope of the referrals.

With respect to the referral to the State EPA under the EP Act, the scope of a Proposed Action is limited to infrastructure within State waters.

1.5 Legislative Framework

1.5.1 Applicable Commonwealth Legislation and Policies

Key Commonwealth legislation applicable to the Proposed Action are the EPBC Act and the OPGGS Act.

The EPBC Act is the Commonwealth Government's primary environmental legislation. These are the principal statutes for the protection and management of matters of national environmental significance (matters of NES).

Under the EPBC Act, any action that is likely to have a significant impact on matters of NES must not be taken without the approval of the Minister. Actions with the potential to significantly impact on a matter of NES trigger the Commonwealth environmental assessment and approval process.

The OPGGS Act provides a framework for all offshore petroleum exploration, recovery and production and Greenhouse Gas (GHG) storage activities in Commonwealth waters. The Act is supported by regulations and directions that cover matters of safety, diving, petroleum resource management and environmental management.

A number of assessments are required under the OPGGS Act from the Designated Regulatory Authority in order to construct, operate and decommission a petroleum facility.

The related OPGGS (Environment) Regulations 2009 (OPGGS (E) Regulations) have been set out to ensure any petroleum activity is consistent with the Environmental Sustainable Development (ESD) principles and carried out in a manner by which the environmental impacts and risks of the activity will be reduced to As Low As Reasonable Practicable (ALARP) and will be of an acceptable level (DOE 2014).

Other Commonwealth legislative requirements for the Proposed Action, in addition to the EPBC Act and OPGGS Act, may include but are not limited to:

- *Australian Heritage Council Act 2003*
- *Biosecurity Act 2015*
- *Biosecurity (Ballast Water & Sediment) Determination 2017*
- *Civil Aviation Act 1988*
- *Environmental Protection (Sea Dumping) Act 1981*
- *Hazardous Waste (Regulation of Exports and Imports) Act 1989*
- *Historic Shipwrecks Act 1976*
- *Underwater Cultural Heritage Act 2018*
- *National Greenhouse and Energy Reporting Act 2007* (NGER Act)
- *Navigation Act 2012*
- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
- *Protection of the Sea (Harmful Anti-fouling Substances) Act 2006*
- *Submarine Cables and Pipelines Protection Act 1963*
- *Native Title Act 1993.*

The following Commonwealth Government policies regarding petroleum development and marine protection relevant to the proposed development:

- Australian Offshore Petroleum Development Policy
- Australia's Oceans Policy

- Marine Bioregional Plans
- Conservation Advices
- Species Management Plans
- Recovery Plans
- Clean Energy and Emissions Reduction Fund
- EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales
- Australian Ballast Water Management Requirements 2017
- National Biofouling Management Guidance for the Petroleum Production and Exploration Industry 2009
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000.

1.5.2 Applicable State Legislation

Key State legislation applicable to the Proposed Action are the EP Act and the *Petroleum (Submerged Lands) Act 1982* (PSL Act).

The EP Act is WA's primary environmental legislation. The Act sets out to prevent, control, and abate pollution and environmental harm, for the conservation, preservation, protection, enhancement, and management of the environment. The EPA has statutory obligations under the EP Act to conduct EIAs, initiate measures to protect the environment from environmental harm and pollution and to provide advice to the WA Minister for Environment on environmental matters.

The PSL Act provides the regulatory framework for the exploration and production of petroleum resources located within State marine waters, including related pipelines.

Other State legislative requirements potentially relevant to the Proposed Action and Proposal may include, but are not be limited to:

- *Biosecurity and Agriculture Management Act 2007*
- *Biodiversity Conservation Regulations 2018*
- *Conservation and Land Management Act 1984*
- *Fish Resources Management Act 1994*
- *Land Administration Act 1997*
- *Maritime Archaeology Act 1973*
- *Petroleum and Geothermal Energy Resources Act 1967*
- *Petroleum (Submerged Lands) Act 1982*
- *Pollution of Waters by Oil and Noxious Substances Act 1987*
- *Waste Avoidance and Resource Recovery Act 2007*
- *Wildlife Conservation Act 1950* (WA) (WC Act).

The EPA has developed a series of guidance statements for the assessment of environmental impacts in accordance with Part IV of the EP Act. The guidance statements are designed to assist project proponents and the public to understand the requirements for protection of the environment under the EP Act. The guidance statements referred to in preparing the EP Act referral include:

- Instructions for the referral of a Proposal to the Environmental Protection Authority under Section 38 of the *Environmental Protection Act 1986* (EPA 2018)

- Environmental Impact Assessment (EIA) (Part IV, Divisions I and II) Administrative Procedures (EPA 2016)
- Statement of Environmental Principles, Factors and Objectives (EPA 2016b)
- Environmental Factor Guideline - Benthic Communities and Habitats (EPA 2016c)
- Technical Guidance - Protection of Benthic Communities and Habitats (EPA 2016d)
- Environmental Factor Guideline - Coastal Processes (EPA 2016e)
- Environmental Factor Guideline - Marine Environmental Quality (EPA 2016f)
- Technical Guidance - Protecting the Quality of Western Australia's Marine Environment (EPA 2016g)
- Environmental Factor Guideline - Marine Fauna (EPA 2016h)
- Environmental Assessment Guidelines: Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EAG 5) (EPA 2010)
- Environmental Factor Guideline - Air Quality (EPA 2016i)
- Environmental Factor Guideline - Social Surroundings (EPA 2016j).

2. Detailed Description of Proposed Action

2.1 Development Overview

The following section describes the key characteristics of the Proposed Action. It should be noted that information in this section is based on knowledge of the Proposed Action which is currently in Basis of Design (BOD) phase. While it is expected that environmental aspects and associated potential impacts described here will remain unchanged overall, the proposed development concept and associated activities may be subject to amendments as the design and detailed engineering studies mature.

As detailed in **Section 1.4.2**, appraisal and feasibility studies including seismic surveys and appraisal wells do not form part of the Proposed Action.

2.1.1 Project Area

The Project area consists of:

- The proposed Browse Development Area comprises the Brecknock, Calliance and Torosa fields, the FPSO facilities and the subsea production systems, including wells.
- The proposed pipeline corridor within which the BTL and inter-field spur line will be located from the proposed Browse Development Area to the tie in point near NRC.

The proposed Browse Development Area is shown in **Figure 1**. The BTL and inter-field spur line route are shown in **Figure 2**.

The bounding coordinates of the proposed Browse Development Area are provided in **Table 1**. The key coordinates of the inter-field spur line and BTL are provided in **Table 2**. It should be noted that a geophysical, geotechnical and environmental survey of the BTL route will be undertaken and refinement of the indicative route is likely to occur. These surveys of the BTL route do not form part of the Proposed Action. The final route and development corridor will be identified in the formal EIA documentation.

Table 1 Coordinates of the proposed Browse Development Area

Boundary Point	Coordinates (GDA94)	
	Longitude	Latitude
1	121.50126	-14.581948
2	121.41793	-14.581949
3	121.41793	-14.498615
4	121.50126	-14.498615
5	121.50126	-14.331948
6	121.58459	-14.331947
7	121.58459	-14.248613
8	121.66793	-14.248613
9	121.66793	-13.998612
10	121.73711	-13.998612
11	121.75126	-13.99273
12	121.75126	-13.915278
13	121.91792	-13.915277
14	121.91792	-13.831943
15	122.16792	-13.831942
16	122.16792	-13.915275
17	122.08459	-13.915276
18	122.08459	-14.081943
19	122.00126	-14.081943
20	122.00126	-14.165277
21	121.91793	-14.165277
22	121.91793	-14.227459
23	121.87802	-14.248612
24	121.75126	-14.248612
25	121.75126	-14.66528
26	121.66793	-14.66528

Boundary Point	Coordinates (GDA94)	
	Longitude	Latitude
27	121.66793	-14.748614
28	121.5846	-14.748615
29	121.5846	-14.665281
30	121.50126	-14.665281
31	121.50126	-14.581948

Table 2 Coordinates of the BTL

Boundary Point	Coordinates	
	Easting	Northing
1 (BTL start, near Torosa)	395 120.91 E	8 454 068.40 N
2 (Calliance FPSO)	347 532.36 E	8 393 118.63 N
3 (near tie-in point)	409 108.96 E	7 834 258.23 N

2.1.2 Key Characteristics - Overall Development

The proposed Browse to NWS development comprises subsea infrastructure and 2 x FPSO facilities to be located approximately 290 km north-west of mainland Australia, and approximately 425 km north of Broome, Western Australia; connected to existing NWS Project infrastructure via a ~900 km BTL.

To achieve optimal hydrocarbon recovery, it is anticipated that 13 wells are required for RFSU of the two FPSO facilities, and up to 49 wells are currently anticipated over field life. Indicative numbers of wells are presented in **Table 3**. As detailed in **Section 1.2.4**, a reference case has been developed which will be progressed during BOD.

Table 3 Proposed Development Components

Component	Ready for Start Up (RFSU)	Full Field
Development Well Count – Calliance Reservoir	6	20
Development Well Count – Brecknock Reservoir		7
Development Well Count – Torosa Reservoir	7	22
Subsea infrastructure	Manifolds, flowlines, umbilicals, risers, anchors and moorings	
Surface Facilities	Two by ~1100 MMscf/d (annual daily average) FPSO facilities	
Browse Trunkline (BTL)	~900 km 42" diameter trunkline with adequate capacity for export of 1,800 MMscf/d.	
Inter-field spur line	~85 km 36" diameter spur line with adequate capacity for export of up to 1100 MMscf/d (annual daily average).	

The total extent of seabed disturbance required for the installation of subsea infrastructure for the proposed Development is provided in **Table 4**. These values are subject to refinement during the design process.

Table 4 Extent of Seabed Disturbance

Infrastructure – proposed Browse to NWS development	No.	Length (m)	Width (m)	Area (ha)
Installation Disturbance				
D&C (ie MODU transponders, anchors at each drill centre)				0.2
SURF/BTL installation (wet storage during installation)				5.0
FPSO installation (pre-lay disturbance)				2
Permanent Infrastructure Disturbance				
Wells, SURF, FPSO moorings Flowline network (includes CRA flowlines and EHU)				100 per FPSO
Browse Trunkline (BTL)	1	900,000	10	900
Inter-field spur line	1	85,000	10	85
			Total	**1192**

2.1.3 Development within State Waters

Within State waters, the Proposed Action comprises the proposed development of up to an estimated 21 wells targeting the hydrocarbon resources of the Torosa reservoir. Extracted hydrocarbons will be transferred via subsea infrastructure, including wellheads, manifolds and flowlines, up to the FPSO facilities, located in Commonwealth waters.

Activities in State waters comprise a limited subset of infrastructure and activities (**Table 5**). The highest intensity of activities will likely occur during the drilling and completion activities, installation activities and future decommissioning phases; during which time, a mobile offshore drilling unit (MODU) and vessel numbers of approximately ten or less may be present in the State waters. As all infrastructure within State waters is subsea, operation of the wells will be controlled remotely from the FPSO facilities that are located in Commonwealth waters. Outside of drilling and completion and installation periods, surface activities in the State waters will comprise inspection maintenance and repair activities involving one or two vessels, later phase drilling and decommissioning (including well plug and abandonment).

The WA EPA have provided instructions on how to define the key characteristics of a proposal including the recommended template (EPA 2018b). The key characteristics of the Proposed Action within State waters is shown in the recommended template in **Table 5**. The proposed Browse Development Area including that within State waters is shown in **Figure 1**.

Table 5 Key Characteristics – Development within State Waters

Proposal Summary		
Proposal Title	Proposed Browse to NWS development (State waters components)	
Proponent Name	Woodside Energy Ltd, on behalf of the Browse Joint Venture participants	
Short Description	Drilling and completion, installation, commissioning, operation, well repair and workover and decommissioning of subsea wells and associated subsea infrastructure located in Western Australian State waters, to extract hydrocarbons from the Torosa reservoir, located approximately 425 km north of Broome and approximately 290 km off the Kimberley coast.	
Element	**Description**	**Proposed Authorised Extent**
Physical Elements		
Drilling and completion activities of up to approximately 21 wells	Installation and physical presence of infrastructure within indicative field layout as per **Figure 1**.	Approximately 20 ha of seabed.
Associated subsea infrastructure (wellheads, manifolds, flowlines, and umbilicals)		
Mooring of vessels and MODU		
Seabed preparation and flowline stabilisation		
Operational Elements		

Water Supply (construction vessels, MODU, inspection, maintenance and repair (IMR) vessels, condensate tankers, supply boat operations, support vessel operations)	Water requirements sourced either from seawater (reverse osmosis plant) or loaded at port.	Limited water requirements to support drilling and completion activities, vessel and MODU water needs and potentially also for hydrotesting and decommissioning activities.
Power Supply (construction vessels, MODU, inspection, maintenance and repair (IMR) vessels, condensate tankers, supply boat operations, support vessel operations)	Power generated on board vessels and MODU.	As required for operations and safety.
Vessel discharges (construction vessels, MODU, inspection, maintenance and repair (IMR) vessels, condensate tankers, supply boat operations, support vessel operations)	Discharges include treated sewage, drain waters, cooling water and sullage and desalination brine.	Limited volumes discharged in accordance with International Convention for the Prevention of Pollution from Ships MARPOL 73/78 Annex I, as applied in Australia under the Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Part II Prevention of pollution from oil); Marine Orders 91 (Marine pollution prevention – Oil) 2006 as applicable to vessel class; *Pollution of Waters by Oil and Noxious Substance Act 1986.*
Drill cuttings and fluid discharges	Disposal of drill cuttings and drilling fluids.	Approximately 800 m^3 of cuttings are anticipated to be generated per well. Refer to **Section 2.8.4** for further details.
Hydrotest fluid discharge	Flowlines will be pressure tested with a hydrotest fluid comprising either treated seawater). Following testing, the hydrotest fluid will either be discharged to sea (outside State waters) or routed via the flowline to a FPSO facility for disposal overboard (outside of State waters).	Required hydrotest fluid volumes will vary depending on the flowline section to be tested, from approximately 80 m^3 up to approximately 600 m^3. The frequency of hydrotest fluid discharge depends on the timing of flowline installation and hook-up to the FPSO facilities, and on the fluid type used. Refer to **Section 2.8.3.1** for further details.
Produced water	Small volumes of formation water may result during well clean-up activities by the MODU. These will be discharged directly from the MODU.	Low volumes of water that occurs naturally within the hydrocarbon-bearing geological formations.

Subsea control fluid discharge	Discharge of control fluid to maintain valve functionality.	Intermittent discharge of hydraulic fluid based control fluids when valves actuated (~0.1 L). Refer to **Section 2.8.3.4** for further details.
Underwater noise emissions	Underwater noise generated during drilling and completion and installations activities (including vessels movement on DP). Underwater noise generated from subsea infrastructure during operations. Underwater from piling activities for mooring installation for FPSO and MODU (note that this is unlikely to be required). Underwater noise from condensate tankers, supply boat operations, support vessel operations.	Noise frequencies associated with these activities are described in **Section 2.8.6.2**.
Light emissions – operational lighting	Artificial light emitted by MODUs, installation vessels, condensate tankers, supply boat operations, support vessel operations.	Limited to functional lighting at levels that provide a safe working environment for personnel. Refer to **Section 2.8.6.3** for further details.
Light emissions – flaring	Intermittent flaring from the FPSO facilities and MODU.	As required for operations and safety. Refer to **Section 2.8.6.3** for further details.

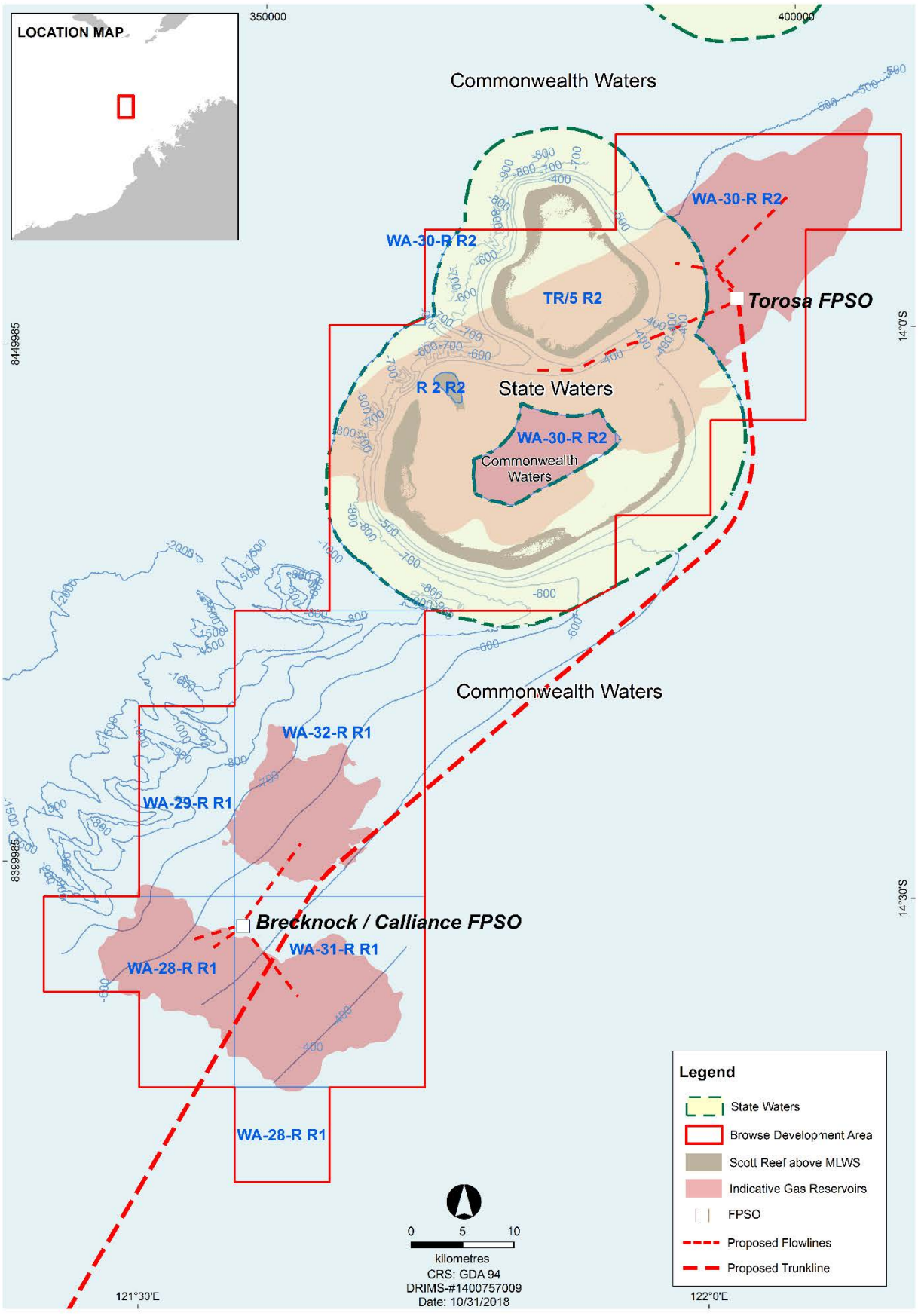

Figure 1 Proposed Browse Development Area

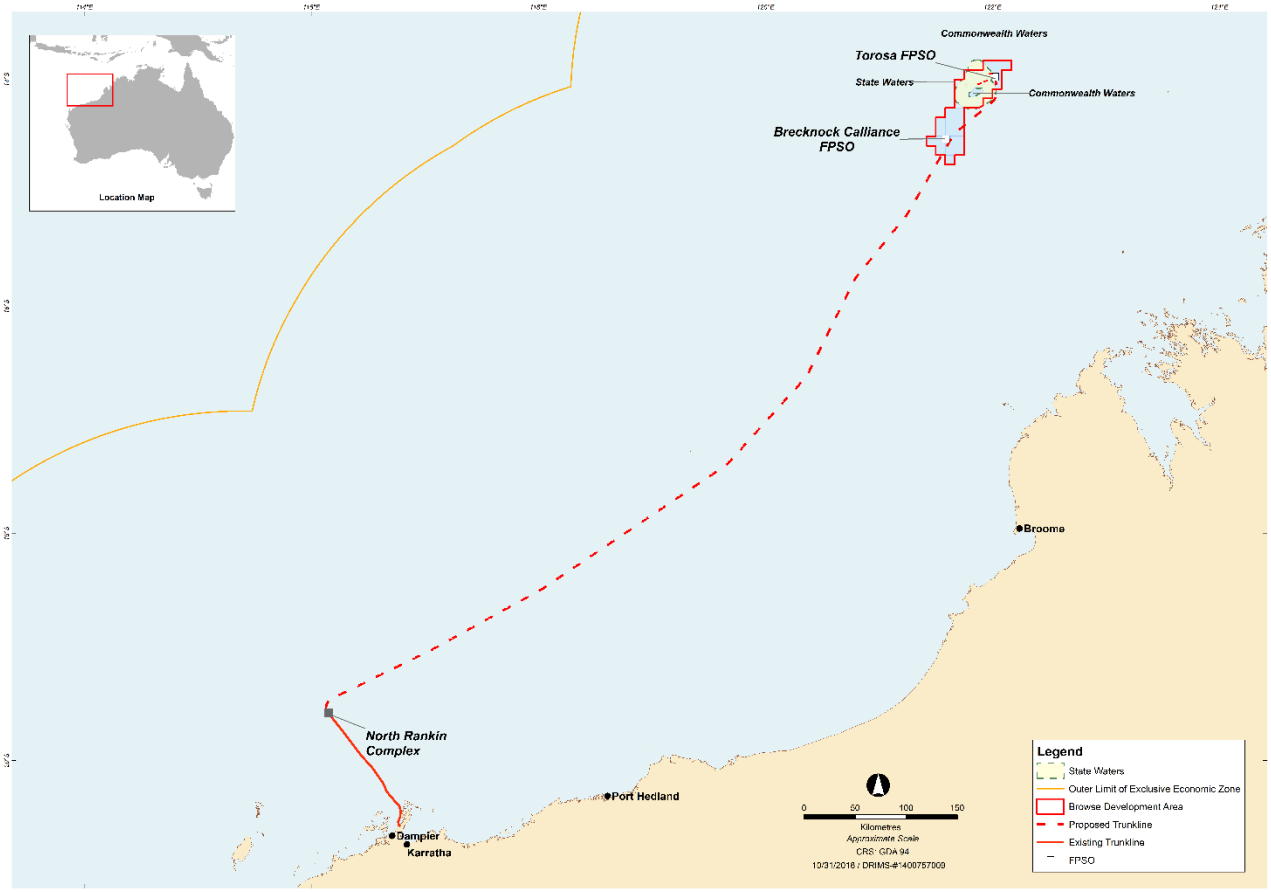

Figure 2 Indicative Browse Trunkline (BTL) route

2.2 Development Schedule

Subject to all necessary joint venture and regulatory approvals being obtained and appropriate commercial arrangements being finalised, indicative timeframes for the proposed Browse to NWS development (Proposed Action) comprise: commencement of construction and drilling and completion activities from approximately 2021 – 2022, followed by installation and commissioning activities, ready for start-up (RFSU) and commencement of operations occurring in the mid-2020s, and operations continuing for up to 50 years. Following operations, decommissioning activities will be carried out as part of the Proposed Action.

2.3 Infrastructure

The proposed Browse to NWS development comprises key infrastructure components such as wells, subsea infrastructure, FPSOs and subsea pipelines (BTL and inter-field spur line). An indicative field layout is provided in **Figure 1**. The indicative BTL route is shown in **Figure 2.**

2.3.1 Wells

It is anticipated that the proposed Browse to NWS development will require drilling and completion of up to 49 production wells at the Brecknock, Calliance and Torosa reservoirs over the life of the Development (refer to **Table 3**).

Note that production wells will be drilled from a number of central drill centres. The number and location of these wells and drill centres will depend on reservoir target areas and seabed bathymetry and features to optimise reservoir recovery. Up to an estimated 21 of the production wells will be located within State waters.

Each well will be topped by a wellhead which provide means of hanging the production well casing, and for installing the christmas tree and well flow control facilities. Each well is then fitted with a christmas tree which enables reservoir fluids to flow from the well to the flowlines. Christmas trees are used to:

- Manage chemical injection
- Control production, whereby hydraulically controlled valves on the christmas trees are used to control flow rates and provide a well shut-off mechanism.

2.3.2 Subsea Infrastructure and Flexible Risers

The wells at each drill centre are connected to manifolds by well jumpers to allow reservoir fluids to be carried from the wells to the manifolds. The manifolds connect the wells to corrosion resistant alloy (CRA) flowlines that are routed back to the FPSOs. Connection between the flowlines and the FPSO facilities is achieved using flexible risers through a Flowline End Termination (FLET) or riser base manifold. The flowlines are insulated and heated to manage wax and hydrate formation. Flowline heating may not be required at all times.

Subsea infrastructure is powered, monitored and controlled from the FPSO facilities using a network of electro-hydraulic control umbilicals and subsea distribution units (SDUs). Each drill centre is serviced by an electro-hydraulic umbilical likely to follow the same alignment as the infield flowlines. Some umbilicals may be integrated within the production flowline bundle. Umbilicals are also tied back to the FPSO facilities using a system of flexible risers.

Other subsea infrastructure includes the FPSO anchors and mooring lines and potentially permanent moorings for support vessels.

Each of the subsea infrastructure types described above will be located in both State and Commonwealth waters except for the flexible risers and mooring turrets which are only located in Commonwealth waters.

2.3.3 FPSO Facilities

Two by ~1100 MMscf/d (annual daily average) export rate FPSO facilities are proposed for the development.

The key features of the FPSO are as follows:

- Ship-shaped Hull (335 m (up to 370 m) x 67 m x 35 m (L-W-D) with approximately 900,000 barrels' effective condensate storage)
- Double side and single bottom hull
- Permanently moored on location by bow mounted internal turret
- Facilities include:
  - Inlet reception
  - Space for depletion compression
  - Water treatment and overboard disposal
  - Condensate stabilisation and compartmentalised storage
  - CO_2 removal
  - Hydrocarbon and water dew pointing
  - Export gas compression
  - Utilities
  - Accommodation
- Tandem condensate offloading.

The FPSO facilities will be located in Commonwealth waters.

2.3.4 BTL and Inter-Field Spur Line

Gas will be exported from the FPSO facilities via a 42" carbon steel trunkline (BTL) that runs approximately ~900 km South West from the Calliance/Brecknock FPSO facility to the tie-in point with the NWS Project infrastructure near NRC. A ~85 km 36" inter-field spur line will connect the Torosa FPSO facility to the 42" trunkline near Calliance/Brecknock FPSO.

The entire length of the BTL and inter-field spur line will be located in Commonwealth waters.

2.3.5 NWS Second Trunkline

From the tie-in point near NRC, the Browse resources will be transported via third party trunkline infrastructure to deliver the gas to KGP. Transportation of the gas from the tie-in point in Commonwealth waters near NRC to the onshore KGP and subsequent processing and export is outside the scope of the Proposed Action.

The BJV understand NWS JV is preparing to refer a proposal which includes long term processing of third party gas (including Browse) at the KGP.

2.4 Development Activities

2.4.1 Development Drilling

2.4.1.1 Drilling Method

It is anticipated that a MODU will be used to drill and complete the wells. Prior to RFSU the MODU will likely be a dynamically positioned (DP) MODU with mooring capability. Post RFSU a moored MODU is likely to be used. A moored MODU is anticipated to be moored using anchors, suction piles or driven piles, similar but most likely smaller, than those used for the FPSO facilities.

Production wells will be drilled to depths of between 3,500 and 4,500 m beneath sea level to intersect the reservoirs. Once the reservoir is reached, the well may be drilled at inclination (up to horizontally) to optimise the length of the well within the reservoir and the recovery of reservoir fluids. These horizontal sections of wells will typically radiate outwards from each well centre in a spokelike arrangement, although this will be influenced by reservoir targets and proximity to other well centres.

Typically, the drilling process starts with the drilling of the largest size hole, and a smaller diameter conductor will be cemented inside this hole. Next, a smaller diameter hole section will be drilled and an intermediate casing will be run in and cemented. Intermediate casings provide structural support for the hole walls, isolate geological formations and allow pressure management that may be experienced during drilling. Additional casing / liner sizes may be required to manage drilling risk.

A blow-out preventer (BOP) and riser system will then be installed. With the BOP in place, a hole will then be drilled to the top of the reservoir and a liner cemented over this hole section. The final hole section is then drilled through the reservoir as required based on reservoir targets.

Wireline logging activities may be undertaken for formation evaluation during drilling. This may include Vertical Seismic Profiling (VSP) or other logging activities containing radioactive sources. Lower and upper completions are then installed followed by the christmas tree. During this installation process the well remains isolated with two independent and verifiable barriers. Typically the BOP is removed in this sequence and replaced with an alternative barrier to maintain two independent and verifiable barriers. The well is then flowed to the MODU. Once stable flow is achieved, the produced fluids are sent to tanks for separation onboard the MODU. The produced gas and condensate is flared while the water is treated to ALARP and then discharged overboard. Controls in relation to this discharge will be determined via the Environment Plan process for development drilling. This first production to the MODU is known as unloading and typically lasts approximately 12 hours per well. Once unloading activities are completed, the wells are then isolated until they are connected up to the FPSO facilities. The precise sequence of the drilling, completions and unloading activity is dependent on the type of christmas tree installed.

Long term water shut-off may be required in wells during field life. This activity or other intervention activities may be conducted using a light well intervention vessel (LWIV) as opposed to a MODU.

Note that drilling and completion of wells, including infill wells, may continue to occur after RFSU in order to optimise hydrocarbon recovery over the field life.

2.4.1.2 Drilling Fluids

Drilling fluids are used to lubricate the drill string, resist any pressure from the wellstream and return cuttings to surface. They are formulated according to the well design, the expected reservoir geological conditions and the surrounding formations.

Drilling fluids are comprised of a base fluid, weighting agents and chemical additives used to give the fluid the exact properties required to make the drilling as efficient and safe as possible. The selection of fluid types will not be finalised until the detailed design phase when well design is more confirmed.

Chemical additives will be selected using Woodside's Offshore Chemicals Selection and Assessment procedure, which includes evaluation based on chemical toxicity.

The top hole sections of the well, before a riser is in place, will be drilled using seawater with bentonite and then bentonite and guar gum sweeps. Once the riser is in place the lower hole sections will be drilled with either water based fluids (WBF) or non-water based fluids (NWBF).

2.4.1.3 Drilling and Completions Unplanned Contingent Activities

There are a number of drilling and completions unplanned contingencies that may be required if operational or technical issues occur. These contingencies do not represent significant additional risks or impacts but may generate additional volumes of fluids being discharged such as drilling cuttings and fluids. These contingencies include well workover, respud, sidetrack, suspension or intervention.

2.4.2 Subsea Umbilicals, Risers and Flowlines (SURF)

2.4.2.1 Site Preparation

Seabed preparation works may be required to position flowlines on a level surface, to provide stability to the subsea gathering system. Seabed preparation may be required in particular through the sand wave region at the eastern entrance to the channel between North Scott Reef and South Scott Reef and within the channel itself. Seabed preparation works will most likely be undertaken using ploughing and/or mass flow excavation techniques. Protection and additional stabilisation methods such as trenching and rock placement may also be required to limit potential damage to flowlines and subsea infrastructure.

2.4.2.2 Installation of Subsea Infrastructure

Subsea infrastructure required for start-up will be installed prior to the arrival of the FPSO facilities, with further infrastructure installed throughout the life of the proposed development, as required. Subsea infrastructure such as manifolds, flowlines, umbilicals, mooring system and risers will be transported to site by a combination of installation vessels and cargo barges. Subsea installation of equipment will be performed by specialist dynamically positioned vessels. These will be equipped with submersible Remotely Operated Vehicles (ROVs), which will aid in the installation, hook-up and commissioning processes.

The manifolds and SDUs will be lowered to the seabed with their position confirmed using acoustic transducers mounted on each manifold. Similar transducers are mounted on each wellhead to ensure the manifold does not contact the wellheads.

With the manifolds in place, the subsea well jumpers, infield flowlines and umbilicals will be installed on the seabed. Flowlines may be either progressively laid or installed as towed bundles.

If flowlines are progressively laid, the infield flowlines will be installed progressively within a defined corridor using a pipe-lay vessel, whereby each flowline is lowered to the seabed as the vessel moves forward. The flowlines will be laid directly on the seabed following seabed preparation (if required) and umbilicals will be laid alongside the flowlines.

If flowlines are installed as towed bundles, then the bundles are fabricated and then towed into position via controlled depth tow. Each bundle is then flooded, allowing it to be lowered into place following seabed preparation (if required).

2.4.2.3 Installation of Flexible Risers

The flexible risers will be installed using a dynamically positioned installation vessel. Typically, one end of each riser will be pulled in and hung off on the FPSO facility using a winch located on the facility. Each of the flexible risers will typically be installed, already filled with MEG or inhibited seawater. To achieve the final riser design configuration, buoyancy modules are generally installed directly onto the riser during the installation. Once each riser has been connected to the FPSO, the subsea end is typically laid to a FLET or riser base manifold. Diverless connectors are likely to be used to connect each riser to the FLET/manifold. The installation of the flexible umbilical risers typically follows the same methodology, however, the umbilicals will be connected to SDUs.

2.4.3 Installation of FPSO Facilities

A turret mooring system will be installed in order to moor each FPSO facility. The configuration is expected to comprise three groups of six mooring lines per group (pending completion of mooring analysis), arranged around the turret. The turret mooring system includes a non-rotating component to support the mooring lines, risers and umbilicals. This configuration allows the facility to freely weathervane with prevailing metocean conditions. Once on location, each FPSO facility will be connected to the mooring system.

The mooring lines will be preferentially secured to the seabed by suction piles. The suction piles will typically be 6 m to 10 m in diameter, and up to 30 m in length, with each weighing approximately 450 tonnes. Given the current uncertainty of seabed conditions (particularly at Torosa), driven piles may be required.

Where suction piling is to be used, piles will be installed by gently lowering the pile onto the seabed and using gravity to lower the pile into the soft substrate. Installation is completed by pumping out the entrapped water inside the pile, with the resulting differential pressure drawing the pile deeper into the seabed. Data from the surveys undertaken by Woodside in 2014 has been analysed and further demonstrate that suction piling for moorings should be feasible and therefore suction piling remains the preferred and most likely option for pile installation. Should driven piling be required, current options being assessed are drilling and cementing or impact piling, which involves the application of force to drive the pile into the seabed.

2.4.4 Installation of BTL and Inter-Field Spur Line

The BTL and inter-field spur line will be installed via a specialised installation vessel. Sections of pipe will be welded together on the vessel before being laid directly onto the sea floor from the stern of the vessel. Typically, these vessels are held in place via dynamic positioning systems. Subsea equipment will typically be lowered into place from a vessel with a crane. Hook up of the equipment on the seabed is typically achieved using ROV's. Up to 20 piles will be installed to secure the riser bases. Initiation anchors may be required temporarily at each end of the pipeline to support installation.

2.4.5 Commissioning

Once installation and hook up of subsea infrastructure is complete, the subsea infrastructure will be subject to pre-commissioning, required to test the integrity of the subsea infrastructure. This will be conducted using hydrotest fluids, whereby the pipeline pressure will be monitored to detect leaks. Fluids will then be left in place to provide corrosion protection prior to the introduction of reservoir fluids. Hydrotest fluid will either be discharged to sea at depth or returned to FPSO and discharged overboard.

Hydrotesting will also be conducted on the BTL and inter-field spur line. The majority of the BTL hydrotest water will be discharged directly to sea at the Brecknock/Calliance FPSO, while the hydrotest water from the inter-field spur line is discharged directly to sea at the Torosa FPSO.

As the FPSO facilities will be constructed at an existing fabrication yard overseas, pre-commissioning of the facilities will be preferentially carried out at the yard, and may include checking, inspection, cleaning, tightness testing, drying and inerting and first fill of process chemicals and adsorbents for the gas treatment system.

Commissioning of the overall production system will be conducted from each FPSO facility on location. Commissioning will include testing, adjusting and monitoring of all systems.

2.5 Operations

2.5.1 Hydrocarbon Extraction

During operations, hydrocarbons extracted from the reservoirs will flow via the christmas trees and manifolds through the flowlines to the FPSO facilities. The flow rate of hydrocarbons will be controlled by subsea choke valves at the wellheads. Subsea hydraulic control fluids will be used to operate subsea valves. During operation of subsea valves subsea hydraulic control fluids may be discharged to the surrounding environment.

2.5.2 Processing

Processing on the FPSO facilities topsides commences with the feed stream being separated into a gas and a liquid stream (condensate and PW). The condensate and PW are then further separated with the PW sent for treatment prior to discharge overboard, with volumes expected to be very low in early field life.

The condensate stream is stabilised and sent to compartmentalised condensate storage tanks prior to offloading. A mercury removal unit will be installed in the condensate system that may be used to meet condensate specification requirements.

The gas will be sent to an acid gas removal unit (AGRU) prior to hydrocarbon and water dew pointing and export compression.

2.5.3 Condensate offload

Up to 50,000 bbls of condensate will be produced daily. Condensate will be loaded on to condensate tankers using flexible hoses every two to four weeks (depending on the production rate), resulting in approximately 12 to 24 oil tanker movements a year per FPSO facility. The oil tankers will then transport the condensate to market.

2.5.4 Gas Export

Transport of the dry gas to the onshore processing facility will be via the pipeline, inter-field spur line and via a trunkline to the NWS infrastructure. Transportation of the Browse resources from the tie in point near NRC using third party trunkline infrastructure and processing of the gas onshore is outside the scope of the Proposed Action. Liquids will not be present in the gas export line.

2.6 Decommissioning

At the end of the Development life, the facilities will be decommissioned in accordance with good oilfield practice and relevant legislation and practice at the time. Decommissioning will occur once the Brecknock, Calliance and Torosa reservoirs have reached the end of their economic life and may occur in stages. This will likely include well suspension and plug and abandoning wells.

In the event that additional reservoirs or third-party reservoirs have been tied into the Development infrastructure, this could increase the development's economic life and thus postpone decommissioning. Consideration will be given to decommissioning during design.

2.7 Support Activities and Infrastructure

2.7.1 Support Vessels and Helicopters

The drilling and completion, installation and commissioning phases will be supported by barges, tugs, survey vessels, supply vessels (thereafter referred to as support vessels) and installation and pipelay vessels. Vessel requirements during the decommissioning phase are unknown at this stage due to uncertainty regarding the methodology to be applied, but it can be expected that decommissioning will use similar vessels to those engaged for installation activities.

The operations phase will require a small number of vessels in attendance in the vicinity of the FPSO facilities for transporting personnel, stores and equipment on a routine basis. The supply vessels will travel between the supply chain and logistics support facility (or facilities) and the FPSO facilities, while tugs will travel to the facility to support offloading as required.

Transfer to offshore facilities will be via Helicopter or vessel. It is anticipated that up to two personnel transfers a week per FPSO facility will be required during normal operations. In times of high activity such as crew changes, shutdowns and major maintenance, it is anticipated that there could be two to three flights per day, or equivalent vessel transfers, per facility.

2.7.2 Communications

Due to the distance of the proposed Development from the mainland, a reliable high-speed communication network will be required between facilities offshore and the mainland. The network will be supplied by connection to a pre-existing fibre optic cable.

2.7.3 Supply Chain and Logistics Support

Requirements for supply chain and logistics support for the proposed Development may include:

- Port access to supply and support vessels for people, equipment and materials transfers to and from the Project area
- Airport access to support fixed-wing aircraft and helicopters for people and supplies transfers to and from the Project area
- Search and rescue capabilities
- Onshore support for receiving, storing, and distributing materials and equipment.

As supply and logistics support for the proposed Development will be utilising existing services and infrastructure which are managed by third parties, such services and infrastructure required for the proposed Development are not considered further as part of this assessment.

2.8 Anticipated Discharges and Emissions

2.8.1 Overview

Routine discharges and emissions will include a combination of liquid discharges, underwater and atmospheric emissions and solid waste discharges.

A qualitative summary of anticipated discharges and emissions during each stage of the proposed Development are shown in **Table 6**. A quantitative breakdown for all emissions is not provided in this SD.

Characteristics of these routine discharges and emissions are provided below and an assessment of the environmental risks they may present are provided in the **Section 6**.

Table 6 Anticipated Discharges and Emissions

Aspect	Development Drilling and Completion (including post RFSU Drilling)	Installation and Commissioning	Operation	Decommissioning
Air and Greenhouse Emissions				
Gaseous emissions	x	x	x	x
Liquid Discharges				
Hydrotest fluids		x	x	
Produced water	x	x	x	x
Cooling water	x	x	x	x
Subsea control fluids	x	x	x	
Desalination brine	x	x	x	x
Drain discharges	x	x	x	x
Sewage and sullage	x	x	x	x
Drill Cuttings and Fluids				
Drill cuttings and fluids	x			
Solid Waste				
Non-hazardous inorganic wastes	x	x	x	x
Putrescible wastes	x	x	x	x
Hazardous waste - chemicals, radioactive and medical	x	x	x	x
Other Emission Sources				
Ballast water and biofouling	x	x	x	x
Underwater noise emissions	x	x	x	x
Artificial light emissions	x	x	x	x

2.8.2 Atmospheric and Greenhouse Emissions

Atmospheric and greenhouse gas (GHG) emissions will occur throughout all phases of the Proposed Action.

GHG emissions generated from the Proposed Action will vary depending on activities and operational requirements. Maximum annual emissions of up to ~7Mt CO2-e/year and average annual emissions of ~4Mt CO2-e/year have been estimated. This is inclusive of all vented reservoir gas, the drilling, installation and commissioning, 50 year of operations, and associated decommissioning activities, associated with the offshore Proposed Action only.

Further detail on each of the key sources of greenhouse gas emissions associated with the Proposed Action are described below.

Combustion

During drilling and completion, installation and commissioning the main contributor to GHG emissions will be associated with power generation on the facilities. Fuel source for these periods will be diesel.

During routine operations, the main contributor to GHG emissions will be associated with the combustion of fuel gas in gas turbines used for providing power to the facilities and the export gas compressors on the FPSOs.

Flaring

Flare stacks will be included on the FPSO facilities for the safe combustion of waste gases, as well as gas from the upset conditions such as blowdown. Flaring during commissioning and start-up would be primarily required to manage commissioning and start-up activities safely. During commissioning, the flaring would continue until the full system is operational. Non-routine flaring may result from equipment failure, shutdowns, production restarts, emergency depressurisation, well remediation and well commissioning. In addition, a sequence of planned shutdowns, depressurisations and non-routine (emergency) shutdowns during commissioning would also result in increased emissions from the flare.

Flaring volumes for potential well clean-up and unloading activities have not yet been established. Gas flaring emissions would be calculated during future study phases once firmer estimates of flaring volumes and frequency are available.

Venting

Another source of GHG emissions associated with the proposed Development is the reservoir CO_2 that is separated from the natural gas and directed to atmosphere by a vent line on the flare stack. The three reservoirs making up the Development contain on average 10 mol% CO_2.

Mercury

Mercury may be emitted to the atmosphere during burning of AGRU flash gas (which contains mercury) as fuel, and via venting of the AGRU gas and gas from the PW degasser. In addition, there is some uncertainty as to the extent to which mercury will partition into the amine solvent and be emitted as part of the CO_2 vent on the FPSOs. As such, further work will be undertaken to determine if additional mercury removal units are required.

Nitrogen oxides (NOx) and Sulphur dioxide (SOx)

Nitrogen oxides (NOx) emissions will be produced from gas turbines and flaring operations. The generation of SOx emissions results from the conversion of small amounts of hydrogen sulphide (H_2S) from the fuel gas.

Fugitive emissions

Fugitive emissions of unprocessed natural gas (primarily methane) can arise due to leaks from flanges, control valve seals and compressor seals at the facilities. These will be minimised by the use of welded joints wherever practicable, gas detection systems and preventative maintenance.

2.8.3 Liquid Discharges

2.8.3.1 **Hydrotest Fluid**

In-situ hydrostatic pressure testing will be performed following installation of all flowlines, subsea infrastructure and the BTL/inter-field spur line. This will occur during commissioning and during operations as flowlines are installed to accommodate field layout change or repair. Hydrotesting will require hydrotest fluid to be introduced and left in-situ to protect the infrastructure from corrosion. The period of time hydrotest fluid is left in-situ within the flowlines will depend on the type of fluid selected and the installation schedule for the FPSO facilities.

Hydrotest fluid volumes for the flowline will vary depending on the flowline section to be tested, from approximately 200 m^3 up to approximately 600 m^3 per flowline. Up to approximately 1,000,000 m^3 of hydrotest fluid will be required for the BTL and inter-field spur line hydro testing. Testing of the production riser will also be required and will be undertaken using MEG. Approximately 115 m^3 of MEG will be required per riser.

The selected hydrotest fluid may either be water (typically treated seawater) or MEG. If hydrotest water is selected, it may only be suitable to be left in-situ for a period of approximately 12 months, after which it is typically discharged at sea and the flowline refilled, if required. If MEG is selected, it is likely that it could be left in-situ for longer, therefore, reducing the frequency of discharge to sea.

The hydrotest fluid may consist of a combination of the following chemicals:

- Biocides, corrosion inhibitor and oxygen scavenger (e.g. ammonium bisulphite) to prevent internal pipe corrosion and bacterial formations
- Scale inhibitor to prevent build-up of scale
- MEG
- Fluorescein dye.

The composition of the hydrotest fluid will be determined at a later stage, with chemical selection in accordance with Woodside's Chemical Selection and Approval Procedure.

Prior to installation of the FPSO facilities, flowlines containing hydrotest fluid will be dewatered by pigging using nitrogen and MEG. This hydrotest fluid will be discharged to sea at the manifold location or FLET for each field. Once the FPSO facilities are in place, hydrotest fluids from the subsea infrastructure may be returned to the FPSO and discharged overboard.

BTL and inter-field spur line hydrotest fluid will be discharged directly to sea at the FPSO locations.

Risers may also require integrity testing prior to commissioning. This would be performed using MEG, with the MEG recovered to the FPSO facility for disposal via the PW stream.

2.8.3.2 **Produced Water**

When hydrocarbons are recovered from the reservoir water will also be also produced. This PW may consist of a combination of formation water (water that occurs naturally within the hydrocarbon-bearing geological formations that is drawn into the well during hydrocarbon recovery), and condensed water (water vapour contained in the gaseous phase of the reservoir fluids that condenses out of the gas as the pressure and temperature is reduced). Formation water from the Browse reservoirs is expected to be saline, while condensed water is fresh.

PW may contain inorganic salts from geological formations, dissolved organic compounds, dissolved gases (including H_2S and CO_2), dissolved and dispersed hydrocarbons, metals, low levels of Naturally Occurring Radioactive Materials (NORMs), and production chemicals.

As water is denser than hydrocarbons, formation water is located deeper in the reservoir meaning formation water (and subsequent PW) is expected to be highest towards the end of the reservoir life. The PW treatment circuit at RFSU will be designed for a maximum processing capacity of 1,920 m^3/d. Provision will be made on each facility to increase PW processing capacity to a maximum design rate of 5,723 m^3/d post RFSU. At RFSU, actual PW rates are expected to be significantly less than the design.

PW will be treated to meet defined specifications that meet Woodside and accepted industry standards prior to being discharged overboard. The PW treatment technology to be adopted and the PW discharge location will be determined during development concept definition phase. Proposed PW discharge specifications are presented in **Table 7**.

Table 7 Proposed FPSO PW Discharge Specifications

Description	Units	PW Discharge Limit Average (24 hours)	99% Species Protection Level (within 3Nm of Scott Reef)
Total Oil (including BTEX)	mg/L	30	0.09
Mercury	mg/L	0.03	0.0001
MEG	mg/L	79,000	240

PW that does not meet these standards (for example, due to significant MEG volumes at start up resulting in spikes of concentrations of MEG, Mercury and BTEX); will be stored on board the FPSOs before being blended with steady state PW and processed via the PW treatment process to meet specifications prior to discharge.

It should be noted that the proposed Development has adopted active heating as the hydrate management strategy (versus continuous MEG). As such, there will be no continuous injection of MEG during operations. However, bringing new wells online and for start-up and shut downs, MEG will be injected into the subsea infrastructure. This MEG will be returned to the FPSO and discharged in the PW stream.

Low levels of PW may also be discharged from the MODU during well clean up.

2.8.3.3 Cooling Water

Cooling water will be required for vessels and MODUs involved with drilling and completion, and for commissioning and operation of the FPSO facilities. The largest requirement for cooling water will be from the operation of the FPSO facilities for process cooling.

The FPSO facilities are proposed to have an indirect cooling water system where seawater is pumped up to the facility, treated with hypochlorite and passed through the heat exchangers prior to discharge overboard. It is estimated that the seawater demand will be 20,500 m^3/h per FPSO facility. Significantly lower volumes will be required by support and construction vessels and the MODU.

The discharge temperature of the seawater from the FPSO facilities will be above the average ambient seawater temperature at the site.

The hypochlorite system will inject chlorine to protect the seawater cooling system from biofouling. Residual chlorine will be discharged overboard as part of the cooling water discharge stream. Residual chlorine levels will be monitored and routinely maintained not to exceed 0.2 parts per million (ppm) at the point of discharge. Higher concentrations of up to 0.5 ppm may occur at times, if shock dosing is required.

2.8.3.4 **Subsea Control Fluids**

There are two types of subsea control systems (high pressure and a low pressure system) employed to operate the subsea valves depending on the operations of service. The majority of subsea valves are operated on the low pressure control system.

An open loop subsea control system will be adopted for the high pressure control system, whereby the control fluid is pressurised on the FPSO facilities in hydraulic accumulators and delivered to subsea valves via umbilicals. For the low pressure control system an open loop and a hybrid closed loop solution is being assessed.

In a standard open loop system, subsea control fluids are discharged during valve operation (intermittent hydraulic fluid discharges of ~0.1 L), in contrast to a closed loop system where control fluids are returned back to the FPSO facility.

As per Woodside's Chemical Selection and Approval Procedure, the selected subsea control fluid will have an OCNS rating of Group D or better.

2.8.3.5 **Desalination Brine**

MODU, installation vessels and operational support vessels may either produce fresh water by means of reverse osmosis or thermal desalination or load fresh water at port. Where fresh water is produced onboard vessels, MODU or the FPSO facilities, the desalination process will result in a desalination brine discharge, typically 20 to 50% higher in salinity than the intake seawater (depending on the desalination process used), and may contain low concentrations of anti-scale chemicals.

Freshwater and demineralised water for potable and other uses will be produced on the FPSO facilities using reverse osmosis units, supplied with a seawater feed. Following processing, the RO units will result in a supply of fresh and demineralised water at a total rate of 21.5 m^3/h. The volume of the desalination brine discharge will vary and be dependent on the requirement for potable water on each FPSO facility, vessel or MODU at any given time.

2.8.3.6 **Drain Discharges**

Bunds on the FPSO will be designed to capture and contain discharges and liquid spills that may be expected during steady-state operations and/or planned maintenance activities. Drainage from the MODU and FPSO facilities' bunds will typically be collected and routed through drain collection tanks to slops tanks for treatment. Oil will be recovered and treated water (less than 15 milligrams per litre (mg/L) oil-in-water) discharged overboard.

These drains will be equipped with an overflow arrangement which is designed to allow large volumes to flow directly overboard, which may occur during heavy rains, operation of the fire deluge system or during a major liquid spills where there is a life safety imperative.

2.8.3.7 **Sewage and Sullage**

Sewage and sullage as grey water generated from domestic processes such as dish washing, laundry and showers will be generated on the MODU, support vessels and the FPSO facilities.

Sewage volumes generated will vary depending on the number of personnel on board each FPSO facility and will range from approximately 10 m^3/day per facility during routine operations to 30 m^3/day per facility during maintenance events. Sewage will be treated prior to discharge in accordance with MARPOL 73/78Annex IV: Sewage – (as applied in Australia under Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*); AMSA Marine Orders - Part 96: Marine Pollution Prevention – Sewage. as applicable to vessel class.

2.8.4 Drill Cuttings and Fluids

Cuttings generated during drilling of the wells within the drill centres are expected to range in size from very fine to very coarse particles. Based on an indicative well design, approximately 750-850 m^3 of cuttings are anticipated to be generated per well. An indicative well profile including cutting volumes is shown in **Table 8**. Minor amounts of drilling fluid may adhere to drill cuttings, with small sized cuttings more difficult than larger cuttings to separate from drilling fluid (Neff 2005).

Table 8 Indicative Cuttings Volumes and Fluid Type for Typical Browse Well

Indicative Hole Size	Indicative Drill Length	Indicative Cuttings Volume (m^3)	Indicative Fluid Type
42”	50	45	Seawater with bentonite sweeps
26”	200	69	Seawater with bentonite sweeps
16”	3644	473	Seawater with bentonite and guar sweeps with PHB
12 ¼”	1266	96	Water Based Fluid (WBF) or Non Water Based Fluid (NWBF)
8 ½ “	2325	85	WBF or NWBF
Indicative Total		**768**	

Top hole sections (typically 42, 26 and 16-inch hole sections) will be drilled prior to installation of a riser. Drill cuttings generated from top hole sections during riserless drilling will be discharged directly to the seabed. Drill cuttings from bottom hole sections (typically 12 ¼ and 8 ½ inch hole sections), generated post riser installation, will be returned to the MODU for treatment.

The MODU to be utilised during development drilling and completion will be fitted with typical solids control equipment, which may include, but is not limited to, shale shakers, cuttings dryers and centrifuges to separate the remaining fluid from the cuttings.

Typical treated WBF cuttings may contain 5 to 25% drilling fluid after passage through solid control equipment (Neff 2005). Cuttings from the use of NWBFs may retain 5 to 15% of the drilling fluid (Neff *et al*. 2000). Drill cuttings will be tested to confirm that the average oil on cuttings for the entire well (sections using NWBM) will not exceed 6.9% by wet weight prior to discharge.

NWBFs will be selected in accordance with Woodside’s chemical selection procedure on the basis of lowest health, safety and environmental risks while meeting operational requirements.

2.8.5 Solid Waste

2.8.5.1 Non Hazardous Solid Waste

Non-hazardous waste may include scrap metal, packaging, wood, cardboard, paper and empty containers. Such waste will be segregated at source into recyclable and non-recyclable wastes, where a net environmental benefit is likely, and stored in marked containers for transport onshore to a recycling contractor wherever practicable, or waste disposal site.

2.8.5.2 Putrescible

Food scraps and other putrescible waste will be produced from each FPSO facility (approximately 1L/person/day), MODU and support vessels during all phases of the proposed Development.

2.8.5.3 Hazardous Waste

Hazardous waste generated during the proposed Development would include recovered solvents, excess or spent chemicals, hydrocarbon contaminated materials (e.g. sorbents, filters and rags), batteries, biological wastes from medical facilities, mercury contaminated materials and used lubricating oils.

General hazardous waste will be segregated into recyclable and non-recyclable wastes where a net environmental benefit is likely and stored in clearly marked containers prior to transfer onshore to an approved recycling contractor wherever practicable, or waste disposal site. Hazardous waste will be handled and stored in accordance with the safety data sheets (SDS) and tracked from source to its final destination.

In addition to the general hazardous waste types listed above, mercury and NORM contaminated waste may also be produced during the development. Due to the hazardous nature of spent mercury adsorbent material, vendors recommend immediate offloading into approved containers for the transportation of hazardous materials.

Solid material (including scale and produced sands) collected as part of the processing onboard the FPSO facilities will require disposal. Depending on the characteristics of the Browse reservoirs, collected solid material may be contaminated with NORM and/or mercury. Solids will be treated as hazardous waste and tested to determine appropriate disposal pathway.

Significant levels of NORMs are not currently expected at the FPSO facilities, and no special provisions for handling or disposal of NORM-contaminated wastes are expected.

Like most offshore installations, all hazardous waste is shipped on to supply boat to the supply base for appropriate handling and disposal to a licensed facility.

2.8.6 Other Emission Sources

2.8.6.1 Ballast Water and Biofouling

Vessels and MODU will be transiting to and from the proposed Development regularly during the life of the development, with potential for discharge of ballast water or biofouling on hulls, equipment and structures to be installed and operated for the proposed Development to occur.

Installation or support vessels associated with the Development will discharge ballast water (if required) prior to entering waters within 12 nautical miles (Nm) from land, which includes Scott Reef. FPSO facilities, installation and support vessels will also be treated with antifouling paint to prevent marine growth.

2.8.6.2 **Noise Emissions**

Both underwater and atmospheric noise will be generated during the proposed Development. However, only the generation of underwater noise represents a potential environmental risk therefore, atmospheric noise emissions are not discussed further.

Activities that may result in underwater noise emissions include:

- Drilling and completion and installation activities:
  - Drilling and completion
  - Well evaluation using vertical seismic profiling (VSP)
  - Piling to secure mooring lines for the MODU, SURF installations, FPSO turret mooring systems and BTL export riser bases
  - MODU and installation vessel DP
  - Seabed preparation
  - Vessels at all locations
  - Helicopters.
- Commissioning and operational activities:
  - Subsea infrastructure operation (e.g. choke valves)
  - FPSO routine operation
  - Support vessel and FPSO facility operations (using thrusters) during condensate offloading
  - Vessels at all locations
  - Helicopters
  - IMR activities.

Drilling and Completion, Installation and Commissioning

MODUs: Noise associated with a moored MODU will be restricted to drilling, completion and unloading activities, such as drill pipe operations and on board machinery. A range of broadband values (59 to 185 dB re 1 µPa at 1 m (RMS SPL)) have been quoted for various MODUs (Simmonds *et al.* 2004), where noise is likely to be between 100 to 190 dB re 1 µPa at 1 m (RMS SPL) during drilling and between 85 to 135dBre 1 µPa at 1 m (RMS SPL) when not actively drilling. A noise assessment for a DP MODU, the Stena IceMAX, (JASCO 2017) estimated the broadband source level for drilling operations at 188 dB re 1µPa.

Vertical Seismic Profiling: VSP utilises a sound source suspended in the water column and recorders located down hole to provide a high-resolution seismic image of the immediate vicinity of the well. VSP typically uses up to 3 airguns of 250 cubic inches (cu.in) each (total of 750 cu.in), discharged approximately five times at 20 second intervals, resulting in sound levels of approximately 238 dB re 1 µPa at 1 m (zero to peak pressure level) (Matthews 2012), with dominant frequencies less than 200 Hz. Sound levels are expected to attenuate rapidly to approximately 180 dB re 1 µPa (zero to peak) within 100 m (Matthews 2012). The process is repeated as required for different stations in the well and may take up to 10 hours to complete.

Mooring Installation: The MODU is most likely to use anchor moorings at most drill centre locations however piling may be required. Although noise levels associated with suction piling have not been reported, they are expected to be low as the only source of noise associated with suction piling is the pump (Department of Planning, Transport and Infrastructure 2012). Data from the surveys undertaken by Woodside in 2014 has been analysed and further demonstrate that suction piling for moorings should be feasible and therefore suction piling remains the preferred and most likely option for pile installation.

In the event that driven piles are required, underwater noise will be generated, the level of which may vary depending upon the characteristics of the piles and the pile driving arrangement that is chosen. Existing measurements for subsea pile driving are limited but indicate that source levels are comparable with surface pile driving. McHugh *et al.* (2005) predicted a broadband peak source level for subsea pile driving of 210 dB re 1 µPa at 1 m for a 0.75 diameter pile in 95 m water depth, based on measurements collected at a range of 500 m. For comparison, an abundance of literature on surface pile driving in shallower water consistently indicates that peak source levels between 200 dB re 1 µPa at 1m and 250 re 1 µPa at 1m are typical for a broad range of piles up to 5 m in diameter, with most energy occurring at frequencies within the first 2 kHz (Nedwell and Howell 2004; Talisman 2005; Parvin and Nedwell 2006; Bailey *et al*. 2010).

If driven piling is required, it is anticipated that one pile would be installed at a time at a rate of approximately one pile per day. Active driving time for each pile would be expected to take between one and six hours within a 24-hour period, depending on environmental conditions. Underwater noise associated with drill and cement piling would be expected to produce low intensity continuous noise, similar to that generated by drill rigs.

Seabed Preparation: Seabed preparation, and additional protection and stabilisation methods that may be required, through direct interaction with the seabed, have the potential to result in noise being transmitted through the seabed as well as through the water column (Wyatt 2008). Noise is likely to be a mixture of broadband noise and tones and levels will be dependent on the physical properties of the seabed (Nedwell *et al*. 2003). Trenching noise has been measured at 178 dB re 1 µPa at 1 m (Nedwell *et al*. 2003) while measurement of rock placement using a fall pipe in 60 to 70 m water depth by Nedwell and Edwards (2004) found noise levels from the activity to be below ambient. In general, the use of thrusters for manoeuvring and positioning vessels is likely to provide the most significant source of noise during seabed preparation and stabilisation activities.

Vessel Movements: Support vessels may emit noise through the hull acting as a transducer (e.g. machinery vibration being converted to underwater noise), as well as through cavitation from fast moving surfaces such as propellers and thrusters. The main source of noise from support vessels (both platform support and subsea support vessels) relates to the use of DP thrusters (i.e. cavitation from thruster propellers). Thruster noise (from cavitation caused by propellers) is typically the most significant noise source for vessels holding station, with other noise sources typically relatively minor (McCauley 1998).

Thruster noise is typically high intensity and broadband in nature. McCauley (1998) measured underwater broadband noise up to approximately 182 dB re 1 µPa at 1 m (rms SPL) from a support vessel holding station in the Timor Sea; it is expected that noise levels up to this this level may be generated by vessels using DP. Sound levels of 137 dB re 1 µPa at 405 m were recorded from a typical offshore support vessel holding station in strong currents (McCauley 1998).

IMR Activities: Acoustic survey may be undertaken as part of IMR activities, including sides can sonar (SSS) and multi-beam echo sounders (MBES) surveys. These methods are typically used infrequently and are not constantly active during these infrequent IMR activities.

Helicopter Movements: Noise may also be associated with helicopter movements that will occur during all phases of the proposed Development. Helicopter noise is emitted to the atmosphere during routine helicopter flights. Noise levels for typical helicopters used in offshore operations (Eurocopter Super Puma AS332) at 150 m separation distance has been measured at up to a maximum of 90.6 dB (BMT Asia Pacific 2005). During noise measurements recorded at Scott Reef during a drilling program in 2008, the noise from helicopters operating around the MODU was not detectable at a noise logger set 4.6 km away (McCauley 2008).

Commissioning and Operations

During normal operations, underwater noise generated by each FPSO facility is expected to be dominated by the noise and vibration generated by onboard machinery within the hull and topsides process equipment. The highest underwater noise contribution is predicted to be during offloading condensate. This activity may involve the simultaneous operation of thrusters on the FPSO facility (to control the heading), thrusters on support vessels and the main engine of the condensate tanker. It should be noted however, that offloading activities are only expected to occur 12-24 times a year.

Erbe *et al*. (2013) undertook underwater acoustic recordings of six FPSO vessels moored off WA. Erbe *et al* (2013) determined the 5th, 50th (median) and 95th percentile source levels (broadband, 20 to 2500 Hz) were 188, 181 and 173 dB re 1 lPa at 1m, respectively. The maximum power spectrum density levels were recorded at the time of offloading.

Noise generated at subsea wellheads is due to the pressure difference between the input and the output pressure of the choke valve and the reservoir fluids flowing through the wellhead. The potential pressure difference, and therefore the potential noise level, will be highest early in reservoir life and will diminish with time.

2.8.6.3 **Artificial Light Emissions**

Artificial light emissions will be generated from two main sources:

- Navigational and operational lighting
- Flaring.

Functional lighting is required on vessels, MODU, and FPSO facilities at levels that provide a safe working environment for personnel. It is anticipated that the majority of light fixtures will be fluorescent lights, with only a small number of high pressure sodium floodlights. Illumination levels of approximately 200 Lux will be used in operational areas.

Additional light emissions are associated with intermittent flaring from the FPSOs and MODU. These will vary in duration and intensity. There will be no continuous flaring during normal operations, with the exception of purge gas (inert gas used to purge the flare line to avoid ingress of air) and pilot gas (fuel gas supplied to keep the flare alight).

3. Stakeholder Consultation

Since 2004, Woodside has undertaken extensive consultation in regard to the development of Browse resources with a wide variety of stakeholders including environment and conservation groups, non-government organisations, Commonwealth, State and Local governments, tourism operators, fishing groups, Indigenous representatives, local business and service providers and local communities. The feedback obtained from these consultations, used extensively as part of the concept selection phase of the development, has also been taken into account when planning and undertaking activities associated with the Proposed Action.

Areas of stakeholder interest, which are of particular relevance to the proposed Browse to NWS development concept include:

- Interaction with protected areas under Commonwealth and State legislation
- Interactions with fisheries
- Understanding of physical and ecological characteristics of the Project area
- Aspects of petroleum development with potential for impact on listed species, such as vessel movements, light, GHG and underwater noise emissions
- Cumulative impacts
- Decommissioning.

Information relevant to the aspects listed above is provided within this document. Management measures for these aspects of particular relevance to the proposed Development have been incorporated into the avoidance and mitigation measures presented in **Section 7**.

To provide ongoing support through the environmental approvals process, as well as throughout the life of the proposed Development, Woodside will maintain the stakeholder assessment and engagement process in place since 2004 to:

- Ensure all relevant stakeholders are identified and communicated to in a timely and effective manner
- Develop communications material in response to stakeholder needs
- Analyse stakeholder feedback to inform decision-making and planning.

Stakeholders who have the potential to be impacted by the Proposed Action will be directly engaged.

4. Studies and information sources

4.1 Overview

The BJV has commissioned a large number of studies over the past 20 years to further the understanding of the physical, biological and socio-economic conditions in and around the proposed Browse Development Area.

These studies contribute to long-term data sets for the Region and the majority have been made available in the public domain. Information on the existing environment gathered through these studies has been supplemented by information from:

- Peer reviewed journals
- Industry and government technical reports
- Standards and guidelines
- DoE resources and published literature including the Species Profile and Threats (SPRAT) database, conservations advice and specie management plans
- Search tools such as the Parks and Wildlife Service (PaWs) NatureMap and an EPBC Act Protected Matters database search to identify listed species and communities potentially occurring in the Project area.

4.2 Completed Studies

Woodside has commissioned approximately 60 studies within the proposed Browse Development Area, Scott Reef and the broader region that span approximately two decades. Studies have included baseline and annual programs for humpback whale, turtle, other marine megafauna and fish species in the region, as well as long-term monitoring of coral and fish communities at Scott Reef.

A significant amount of additional analysis and consultation was also completed during development of the Draft EIS Supplement (published) for the Browse FLNG Concept.

These studies have enabled Woodside to build a comprehensive understanding of the environmental context of developing the Browse resources, to enable identification of the potential environmental impacts and development of the appropriate measures to manage and mitigate these.

Existing specialist studies that are available to support the assessment and management of the Proposed Action include, but are not limited to, those presented in Appendix A.

4.3 Current and Planned Studies

Although the development concept for the Browse resources has changed to the Browse to NWS development concept, many of the potential environmental impacts associated with offshore drilling and completion, installation and operational activities remain unchanged and relevant to the proposed Browse to NWS development concept.

As such, due to the level of work already undertaken for the previously proposed Browse concepts, especially around Scott Reef, it is anticipated that a reduction in field studies/ surveys will be required to support the impact assessment for the Proposed Action.

Woodside is continuing to support the undertaking of studies in and around the Project area however, with the following studies currently being executed:

- Pygmy Blue Whales Reviews Desktop Study – Blue Planet Marine
- Ongoing Long-Term Monitoring Program for Scott Reef and Rowley Shoals - AIMS.

It is expected that the results of these studies will be available for inclusion in any formal environmental impact assessments to be submitted in relation to the Proposed Action.

5. Existing Environment

5.1 Introduction

The environment in and surrounding the proposed Browse Development area has been characterised through desktop reviews and scientific surveys. The area surrounding the reservoirs, proposed facilities and subsea infrastructure in particular have been extensively investigated during the development of previous development concepts, including the FLNG development concept. Woodside has commissioned numerous studies in the area including Scott Reef and the broader region over the last two decades and details of these studies are provided in **Section 4.1**.

As described in **Section 1.3**, the environmental footprint of the facilities and subsea infrastructure (other than the BTL and inter-field spur line) of the Proposed Action is expected to be similar to that of the FLNG development concept. The environment in this area is described in detail in **Section 6** of the Browse FLNG Development Draft EIS (Woodside 2014), with the key characteristics summarised below.

The key characteristics of the environment along and adjacent to the BTL route has also been summarised below. This description is based on significant amounts of available literature.

5.2 Regional Characteristics

5.2.1 Marine Region

The Project area lies within the North-west Marine Region which encompasses Commonwealth waters from the Western Australian / Northern Territory border to Kalbarri, and covers 1.07 million km^2 of ocean. The North-west Marine Region consist of eight provisional bioregions based on ecological similarities, species distribution and oceanographic and seafloor characteristics. The Project area traverses the Timor Province bioregion (Browse Development Area and BTL) North-west Transition bioregion (BTL) and the North-west Shelf Province bioregion (for approximately 130 km near the NRC tie-in point) (Commonwealth of Australia 2012).

The North-west Marine Region has a large area of continental shelf and continental slope, with a range of bathymetric features such as canyons, plateaus, terraces, ridges, reefs, banks and shoals.

The region has high species richness, but relatively low endemicity compared with many other areas in Australian waters. The majority of the region's species are tropical and are found in other parts of the Indian Ocean and western Pacific Ocean. The southern part of the region is a transition zone between tropical and temperate species and corresponds with the northern extent of the range of some temperate species (Commonwealth of Australia 2012).

A range of conservation values exist within the North-west Marine Region including Key Ecological Features (KEFs) of the Commonwealth marine area, protected areas (marine reserves, heritage places and historic shipwrecks); and listed threatened and migratory species including internationally significant breeding and feeding grounds for listed species including humpback whales, turtles, whale sharks, seabirds and migratory shorebirds (Commonwealth of Australia 2012).

The facilities and subsea infrastructure and part of the BTL route are proposed to lie on the Ashmore Terrace within the Timor Province bioregion. Ashmore Terrace is a regional feature spanning the continental margin that has resulted from subsidence on a geological timescale (Jones 1973; Bradshaw *et al*. 1988). The region is shallow, with water depths of less than 500 m over more than 50% of its area. The continental shelf in the northern most part of the region (north of Cape Leveque) is described as a 'rimmed ramp', as the waters over the outer margins of the shelf are shallower than the middle portions. The 'ramp' is a unique feature of the Australian margin in this region, with the rim at its outer edge being the site of a number of coral reefs including Ashmore, Cartier, Scott and Seringapatam Reefs (Commonwealth of Australia 2012).

The majority of the BTL route runs through North-west Transition bioregion along the south eastern boundary at depths of between 280 and 400 m before turning towards the mainland and the NRC tie-in point at a depth of approximately 125 m.

5.2.2 Oceanographic Environment and Coastal Processes

Oceanographic conditions are predominately driven by the two distinct seasons comprising a mild, dry winter (April to September) and a hot wet summer (October to March) with rapid transitional months between the main seasons. The wave climate of exposed waters of the North-west Marine Region is influenced by locally generated wind waves (seas), generally from the west (during summer) and east (during winter) and remotely generated swells. Swell directions can vary widely in the region, depending on wind direction, locations of major storms, and local bathymetric effects that occur in areas such as the shelf break and Scott Reef.

Tides in the North-west Marine Region can be broadly categorised as semidiurnal (two highs and two lows per day) with a diurnal inequality (difference between successive highs and successive lows).

Currents within the region are generated by several components, including tidal-forcing, local wind-forcing, inertial oscillations, shelf waves, seiching, trapped waves and regional current systems including the Indonesian Throughflow.

Oceanic salinity conditions prevail throughout the year with salinity remaining relatively uniform at 34 to 35 PSU.

5.2.3 Sediment

Sediments in the region generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the continental slope and abyssal plain. Approximately 60 to 90% of the sediments in the region are carbonate-derived (skeletal remains of carbonate-secreting marine organisms) (Brewer *et al*. 2007).

Particle size distribution (PSD) analyses showed that sediments in the Browse Development Area near the proposed subsea infrastructure and FPSO facilities are generally classified as muddy sand with variable gravel components. The seabed sediments at the Brecknock, Calliance and Torosa reservoirs are generally soft silt and clay, with areas of sand and stiff, hard and/or cemented material (Fugro 2006; Gardline 2009) (**Figure 3** and **Figure 4**). Laboratory analysis of sediment samples collected near the proposed subsea infrastructure indicated no evidence of hydrocarbon contamination, generally low levels of metal, and nutrient levels typical of carbonate-dominated sediments in remote tropical settings (metal concentrations are generally below ANZECC trigger levels).

Sediments along the BTL route are expected to be dominated by sand as is typical of the continental slope in the North-west Transition bioregion (Commonwealth of Australia 2012).

5.2.4 Water Quality

Water quality in the Browse Development Area near the subsea infrastructure and facilities is typical of an unpolluted tropical offshore environment. Much of the surface water in this area is nutrient poor water transported from the Indonesian Throughflow and has low primary productivity. However, topographic upwelling at Scott Reef draws in cool, nutrient-rich water from the channel into the South Reef lagoon supporting locally enhanced productivity. Oceanic waters around this area are characterised by low turbidity, although relatively high levels of total suspended solids have been recorded near Scott Reef in winter which may reflect a peak in plankton productivity. Metal levels in the water column have been recorded as being generally below laboratory reporting levels.

Water quality along the BTL route is also expected to be typical of a pristine tropical offshore environment.

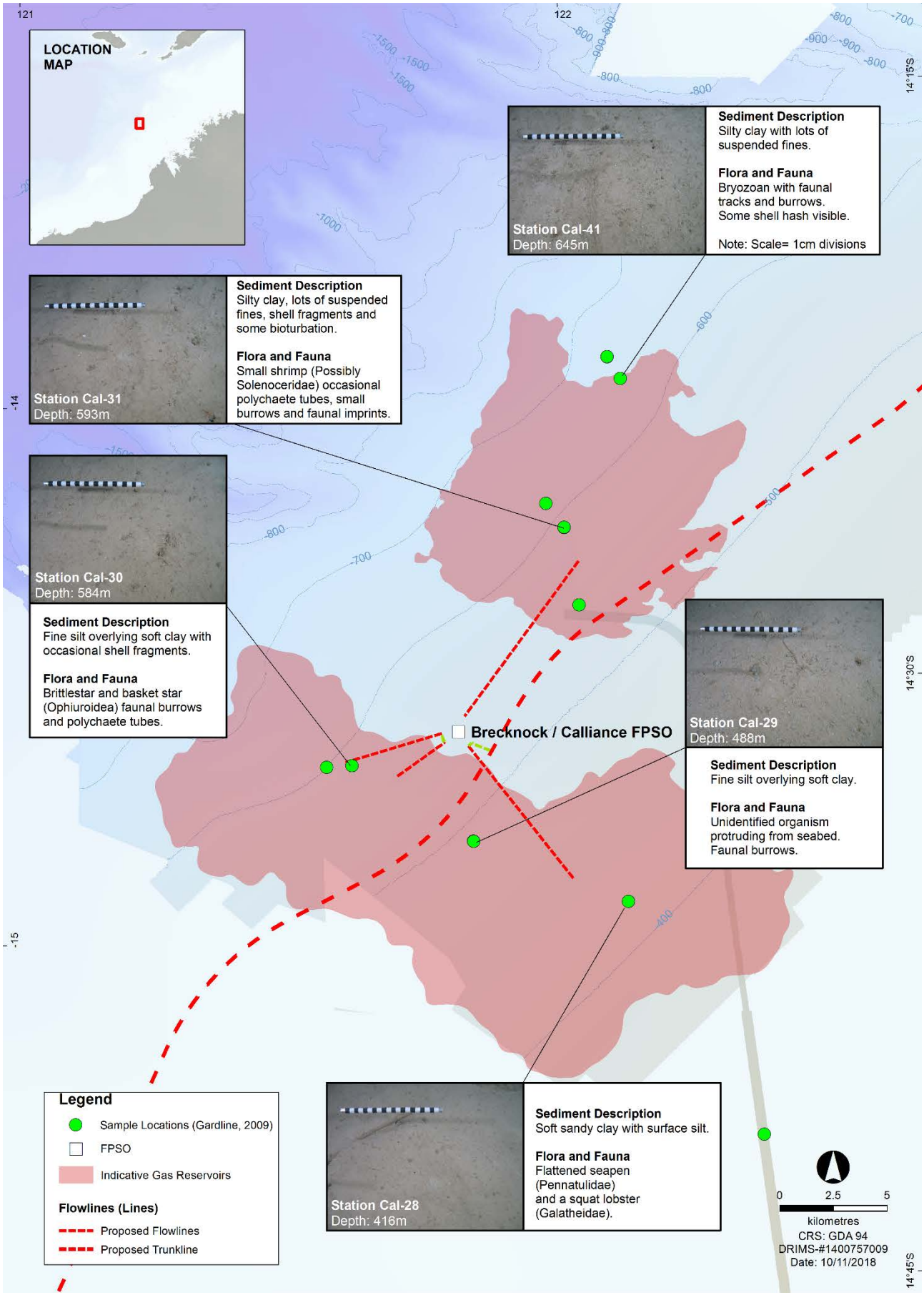

Figure 3 Brecknock and Calliance Field Benthic Habitat Survey (Gardline 2009)

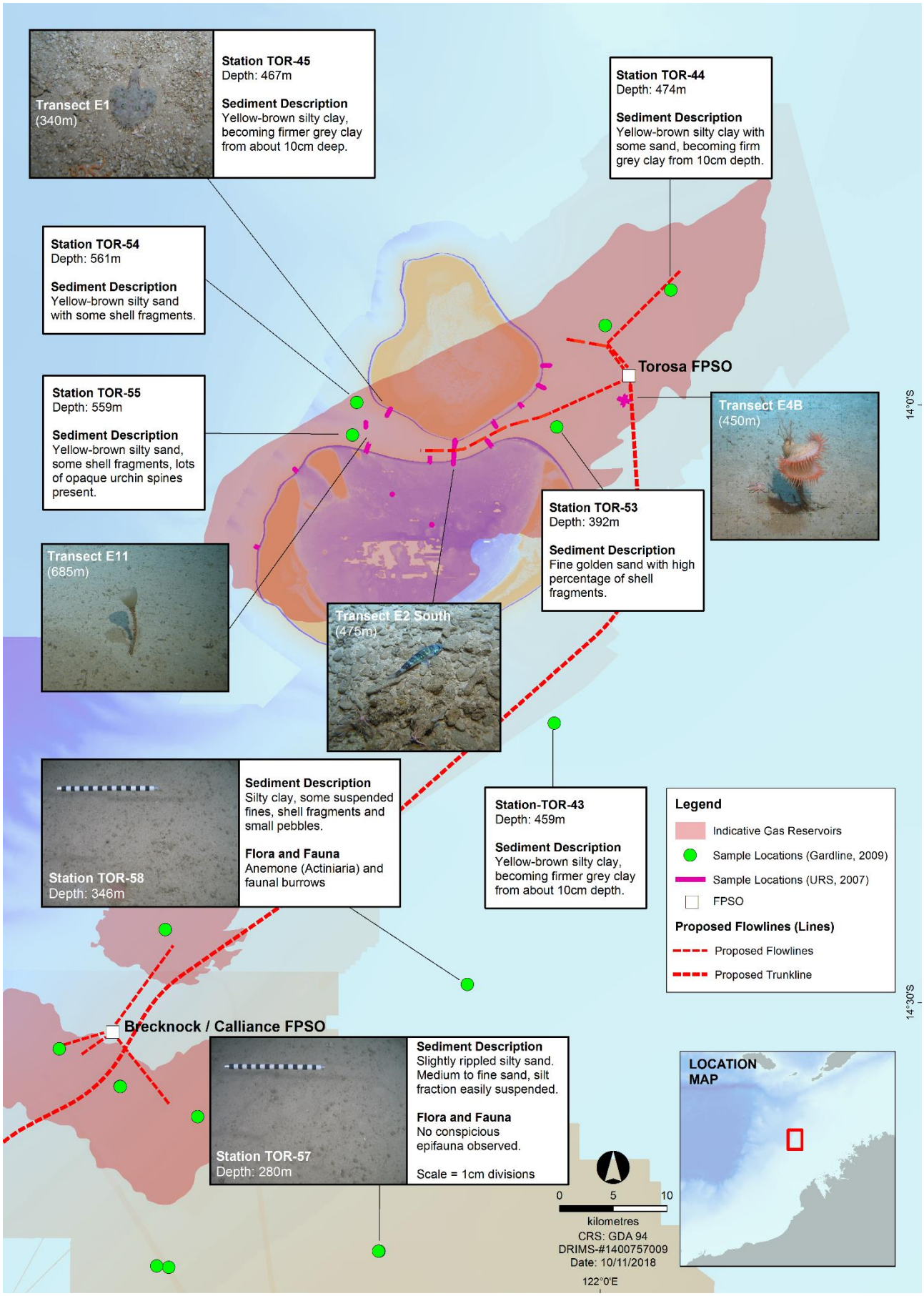

Figure 4 Torosa Field and Surrounds Benthic Habitat Survey (Gardline 2009)

5.2.5 Air Quality

The Project area is offshore and remote from urban or industrial areas. Local air quality is therefore not expected to be significantly influenced by anthropogenic sources.

5.2.6 Light

The Project area is offshore and remote from urban or industrial areas, except where the BTL ties in to the existing NRC facility. Other than light emissions associated with the NRC facility, local light emissions via anthropogenic sources are limited to occasional vessels.

5.2.7 Underwater Noise

The Project area is offshore and remote from urban or industrial areas, except where the BTL ties in to the existing NRC facility. Other than underwater noise emissions associated with the NRC facility, and shipping routes near the BTL route, local underwater noise emissions via anthropogenic sources are limited to occasional vessels.

5.2.8 Submerged and Emergent Reefs and Shoals

5.2.8.1 **Scott Reef**

Scott Reef is a large emergent shelf atoll situated on the outer edge of the continental shelf in both Commonwealth and State waters. The reef is located in close proximity to Browse Development Area. Scott Reef consists of two shelf atolls, separated by a deep channel. North Scott Reef is an annular reef, approximately 17 km long and 16 km wide, and encloses a shallow lagoon about 20 m deep. South Reef is a crescent shaped reef, approximately 20 km wide. The lagoon of South Reef ranges in depth from 20 m to 70 m.

The diverse and complex habitats of Scott Reef provide shelter and food for a highly varied range of primary and secondary consumers. Scott Reef is known to support abundant populations of hard and soft corals, sponges, crustaceans and echinoderms, and diverse fish assemblages in the shallow and deeper waters (Brewer *et al*. 2007; Commonwealth of Australia 2012). Sandy Islet, on the north-west edge of the South Scott Reef, is a known green turtle nesting site. Sandy Islet and the surrounding waters have been identified as habitat critical to the survival of green turtles in the DoEE's Recovery Plan for Marine Turtles 2017-2027 (Commonwealth of Australia 2017).

The closest infrastructure to Scott Reef will be subsea infrastructure that may be situated in the channel between North and South Scott Reef (**Figure 1**). The nearest FPSO facility to Scott Reef will be, located in Commonwealth waters approximately 8 km to the east of Scott Reef.

5.2.8.2 **Rowley Shoals**

The Rowley Shoals are a series of three isolated, reef-rimmed platforms along a north-south orientation that rise vertically to the surface from water depths of about 400 m on the continental slope (Commonwealth of Australia 2012). Rowley Shoals comprise three oceanic reef systems approximately 30-40 km apart, namely Mermaid Reef, Clerke Reef and Imperieuse Reef. Of these, Clerke and Imperieuse Reefs lie in State Waters. Rowley Shoals contain both intertidal and subtidal reefs which support diverse marine fauna. Surveys of the reef have identified 184 species of corals, 264 species of molluscs and 82 species of echinoderms. Unique sponge faunal assemblages also exist on each of the reefs (Commonwealth of Australia 2012).

The marine reef fauna of the Rowley Shoals is considered to be exceptionally rich and diverse, including species typical of the oceanic coral reef communities of the Indo-West Pacific (DEC 2007). The reefs of the Rowley Shoals are ecologically significant in that they are considered ecological stepping stones for reef species originating in Indonesian/Western Pacific waters, are one of a few offshore reef systems on the north-west shelf, and may also provide an upstream source for recruitment to reefs further south. The Rowley Shoals are also identified as breeding grounds for red-tailed tropicbirds, white-tailed tropicbirds and little terns, however numbers are generally low. For example, only a single pair of white-tailed tropic birds nest on Bedwell Island on Clerke Reef.

The BTL route passes close to the Rowley Shoals at a distance of approximately 23 km for Mermaid Reef, 24 km from Clerke Reef and 11 km from Imperieuse Reef.

5.2.8.3 **Seringapatam Reef**

Seringapatam Reef, a shelf atoll, is located approximately 23 km north of Scott Reef and is considered regionally important due to its diversity of fauna. It is an emergent coral reef, but unlike Scott Reef has no permanent island or islet. The reef is characterised by a combination of physical environmental conditions including clear, warm typical of oceanic environments and a large tidal range that provides a high physical energy input to the marine ecosystems.

5.2.8.4 **Rankin Bank**

Rankin Bank is a sedimentary formation located on the continental shelf approximately ~80 km north east of the NRC tie in point. It includes three major banks delineated by the 50 m bathymetric contour with minimum recorded water depths of 18.6 m (LAT), 22.5 m (LAT) and 30.5 m (LAT). The banks represent different habitats from the surrounding seabed, hosting higher faunal diversity. These remote shallow water areas represent regionally unique benthic habitats and are likely to play an important role in the productivity of the Pilbara region (AIMS 2014).

The shoals include habitat areas of macroalgae, hard coral, soft coral, sand and rubble that support a diversity of fish species. These habitats are likely to be relatively pristine, limited in the region but not unique. The significance of these banks is their isolation and relatively shallow depth rather than the composition. A study by Wahab *et al.* (2018) found that Rankin Bank had 20% coral cover which is comparable to that reported for shallow reefs, and the cover of sand, hard corals and sponges supported an abundance and diversity of fish associated with shallow hard coral habitats.

5.2.8.5 **Glomar Shoals**

The Glomar Shoals are an area of the continental shelf elevated above the surrounding seabed, with shallowest depth of the shoals ranging from 22 m to 28 m (LAT), approximately 65 km East of the NRC tie-in point. The seabed comprises biogenic carbonate sediments, dominated by gravel and sand (Falkner *et al*, 2009). The Glomar Shoals has been identified as a key ecological feature of the continental shelf within the North West Marine Region, based on habitat and fish assemblage information (Falkner *et al*, 2009). On a regional level, the Glomar Shoals are not thought to constitute a specific habitat type, although it is considered unique on a local scale. Wahab *et al.* (2018) found that when compared with Rankin Bank, Glomar shoal had up to 30 times less cover of benthic taxa and 1.5 times less fish diversity.

5.3 Ecological Communities

5.3.1 Planktonic Communities

Phytoplankton at Scott Reef and surrounding waters is dominated by picoplankton, particularly the marine cyanobacteria *Prochlorococcus* and *Synechococcus* (Brinkman *et al*. 2009). Estimates of the phytoplankton biomass (measured as chlorophyll a) close to Scott Reef are approximately twice that of open waters (sampled at distances greater than 50 km to the south-west of South Scott Reef). The open water location sampled is likely to be representative of the general outer shelf pelagic environment in which the BTL route lies. This difference is considered to most likely reflect the enhanced vertical mixing of nutrients into the surface layer through interactions between the internal wave field and the local topography (Brinkman *et al*. 2009).

Zooplankton biomass and abundance within the South Scott Reef lagoon tends to be greater in summer than in winter and is dominated by calanoid and cyclopoid copepods (Brinkman *et al*. 2009a). Sampling of the deep water in the channel between North Scott Reef and South Scott Reef suggests that zooplankton is more concentrated in the mixed layer of the channel than at other locations in the area (Brinkman *et al*. 2009).

The waters along the BTL route are expected to be typical of the offshore waters surrounding Australia, containing a relatively low zooplankton biomass, particularly in the open ocean (Tranter 1962).

5.3.2 Benthic Communities and Benthic Primary Producers

5.3.2.1 Browse Development Area

Scott Reef Benthic Habitats

Based on habitat surveys conducted in 1999, 2004 and 2006, AIMS has identified 14 distinct benthic habitat types at Scott Reef; four at North Scott Reef and ten at South Scott Reef as shown in **Figure 5** (Smith *et al.* 2006). A detailed description of each of these benthic habitat types is provided in the Browse FLNG Development Draft Environmental Impact Statement. Overall, habitat types at Scott Reef, which covers approximately 607 km^2, can be broadly grouped into three categories:

- Shallow water habitats (less than 30 m)
- Deep lagoonal habitats (greater than 30 to 70 m)
- Deep-water habitats (70 to 500 m).

The shallow water habitats occupy 170.5 km^2 at North Scott Reef and 147.1 km^2 at South Scott Reef, and include reef crests, flats and slopes, patch reefs and the shallow water lagoons. These habitats support more diverse coral communities than deeper waters but are more susceptible to natural impacts such as thermally induced coral bleaching and cyclone damage. Since 1994, Scott Reef's coral communities have been subject to seven notable disturbances including two wide spread thermal bleaching events (1998 and 2016) that resulted in mortality of over 75% of corals in waters 30 m deep or shallower; two less wide spread bleaching events (2010 and 2011) and three tropical cyclones / monsoonal storms (Gilmour *et al*. 2010, 2011, 2013; AIMS, 2016). The deep-water lagoonal habitats of Scott Reef are extensive, covering approximately 289 km^2. The thermally-induced mass bleaching and cyclones that have affected the shallower habitats of Scott Reef appear to have caused little mortality to these deeper water communities.

The deeper water communities of South Scott Reef are likely to be shaped by available light, current regime and substrate type, and may supplement their energy requirements by feeding on plankton delivered from tidally forced water movements between North Scott Reef and South Scott Reef. The deep-water coral assemblages comprise a subset of species occurring in shallow water habitats (Gilmour *et al*. 2009a).

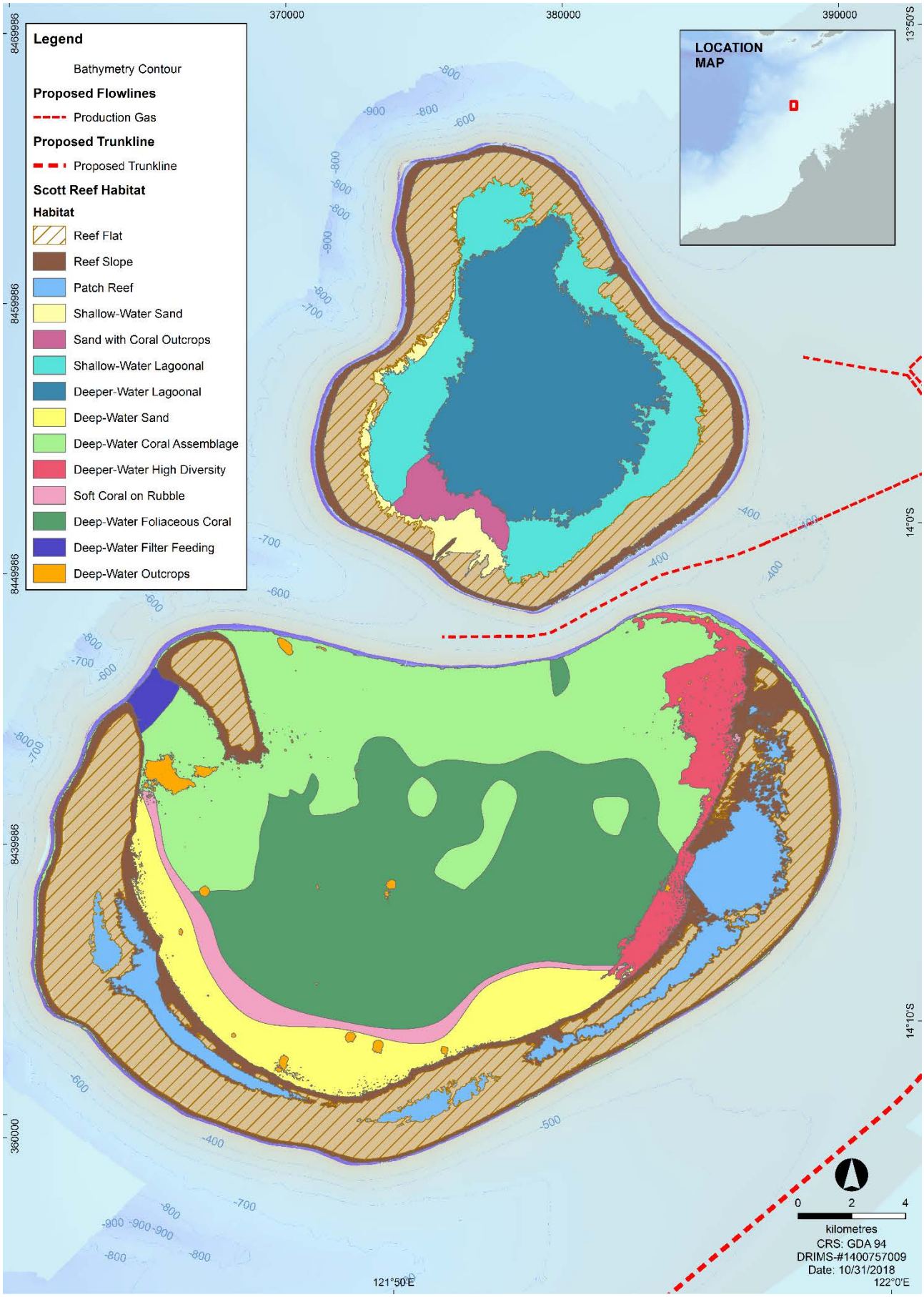

Figure 5 Scott Reef Habitat Map (Smith *et al*. 2006)

Epifaunal Assemblages

Gardline (2009) conducted remote camera surveys at deepwater locations within the Browse Development Area as well as the wider region (**Figure 3** and **Figure 4**). The observed deep-sea seabed at the Brecknock, Calliance and Torosa reservoirs (400 to 600 m) comprised fine sand and silt with epifauna limited to isolated individual bryozoan colonies, brittlestars and basketstars, and sea anemones. As observed in the surveys, Brewer *et al*. (2007) reported that the reservoir areas, consist of muddy substrates with epifauna likely limited to deposit-feeders rather than suspension-feeders such as sponges and soft corals.

Infaunal Assemblages

Gardline (2009) collected infaunal macrobenthos samples (body size of greater than 0.5 mm) from 11 sampling stations in soft sediment benthic habitats across the Browse Development Area. A total of 614 benthic organisms were recorded from 74 taxa, in 43 families from six phyla.

Overall, the most abundant infauna, accounting for 53.4% of all infaunal assemblages, were the polychaete bristleworms from the phylum Annelida, with representatives from 27 families, dominated by the *Spionidae, Syllidae, Eunicida*e and *Nereididae*. Representatives from the sub-phylum Crustacea accounted for 22.5% of benthic infaunal samples, comprising mainly isopods (56.5%), amphipods (20.3%), *Cumacea* (13%), *Malacostracea* (2.9%) and crabs and shrimps (*Decapoda* – 1.4%). The remainder were represented by deep-sea aplacophorans (7.9%), peanut worms (Sipunculidea – 7.1%), brittlestars (Ophiuroidea – 1.4%), peanut worms (Phascolosomatidea – 1.4%), ribbonworms (Nemertea – 1.3%), clams (Bivalvia – 0.8%), and some unidentified individuals (2.11%).

Seagrass

Scott Reef supports five species of seagrass: Thalassia hemprichii, *Thalassodendron ciliatum*, *Cymodocea rotundata*, *Halophila ovalis*, and *H. decipiens* (URS 2006), all of which occur widely throughout the Indo-Pacific region. *T. hemprichi*i is the most abundant seagrass at Scott Reef (Skewes *et al*. 1999; URS 2006). Skewes *et al*. (1999) reported the dominance of *T. hemprichii*, along with less common *H. ovalis* at South Scott Reef, and T. *hemprichi*i and *H. ovalis* as co-dominants, with minor *T. ciliatum* at North Scott Reef, all occurring on the reef edge, lagoon edge and shallow lagoon. Seagrasses recorded in less than 15 m depth covered a total of 23 ha out of 10,613 ha (0.22%) at North Scott Reef, and 77 ha out of 14,400 ha (0.54%) at South Scott Reef.

Water depths at the locations where the subsea infrastructure will in placed are generally too deep to provide suitable conditions for seagrass growth. A benthic habitat survey found no seagrass during within the deeper waters of the Browse Development Area where the subsea infrastructure will be placed (Gardline 2009).

Macroalgae

A total of 121 species of algae have been reported from Scott Reef; however, there is likely to be a number of smaller, cryptic species that have not yet been recorded (WAM 2009; SKM 2009). Two surveys of macroalgae at Scott Reef in 2006 found general algal cover to be approximately 5 to 10% in shallow and intertidal areas, but it was highly variable with some areas approaching 100% cover within the phototrophic zone (WAM 2009). The growth of macroalgae, in the deep waters where the subsea infrastructure will be placed, is excluded due to a reduction or absence of light availability and lack of hard substrate to support attachment in the predominantly soft sediment habitats of the area. A benthic habitat survey found no macroalgal beds within the deeper waters of the Browse Development Area where the subsea infrastructure will be placed (Gardline 2009).

Corals

A diverse assemblage of hard coral species has been recorded from the shallow and deep-water environments at Scott Reef, with 307 species from 60 genera and 14 families (Gilmour *et al*. 2009b, WAM 2009). Gilmour *et al*. (2009b) and WAM (2009) reported similar species, with the exception of *Galaxea longisepta*. Two hundred and ninety-five species have been recorded from shallow-water environments (less than 30 m) and 51 species from deep-water habitats (greater than 30 m).

Eleven hard coral species were recorded only from deep-water locations (Gilmour *et al*. 2009a). Of the corals recorded, none were endemic to Scott Reef. The distribution of soft corals is likely to be driven by water depth and availability of hard substratum. If present within the deeper areas of the Browse Development Area, they are likely limited to scattered isolated individuals. Hard corals are not present in the deep waters of the Browse Development Area due to the predominance of soft substrates and the deeper depths, where light attenuation precludes light-dependant, reef-building coral presence. No soft or hard corals were observed during benthic environmental surveys within the deeper waters of the Browse Development Area where the subsea infrastructure will be placed (Gardline 2009; Hudson & Fletcher 2006; URS 2007).

Non-Coral Marine Invertebrates

Scott Reef supports abundant populations of sponges, crustaceans and echinoderms. A study at Scott Reef in 2006 collected 96 sponge species, with 46 unique to Scott Reef, and although low sponge density was observed, biodiversity was noted to be high (Gilmour *et al*. 2013a; Gilmour *et al*. 2013b; WAM 2009). A ROV inspection of outer-reef habitats of Scott Reef in deep waters recorded sponges from all outer-reef slope habitats (URS 2007a).

A study by WAM (2009) identified 105 and 63 crustacean species at South and North Scott Reef (10 and 14 survey stations respectively). Crustaceans were identified as the fifth most abundant phylum recorded in benthic habitat surveys of the deep-water sands in the southeast of South Scott Reef Lagoon (URS 2007b).

At Scott Reef, the richest area for molluscs was identified to be the lower intertidal area on Sandy Islet (Wells & Slack-Smith 1986). A total of 221 mollusc species were identified from South Reef (14 survey stations) and 183 species from North Reef (10 survey stations) (WAM 2009). A survey of the deep-water sand habitats of the south-east inner reef edge at South Scott Reef found molluscs (bivalves and gastropods) to be among the most abundant phyla. Deep seabed ROV transects conducted around Scott Reef and in the channel between North and South Scott Reef did not report any significant numbers of molluscs (URS 2007a).

Marsh (1986) recorded a total of 117 echinoderm species from Scott and Seringapatam reefs indicating that echinoderms are widespread across all Scott Reef habitats. Recent surveys have recorded fewer echinoderm species although these surveys did not employ comparable sampling methods or effort (URS 2006; WAM 2009).

Benthic surveys undertaken by Gardline in 2009 showed the following biota composition for deep waters where the subsea infrastructure will be placed (Gardline 2009):

- Sessile epifauna such as sponges are sparsely distributed
- Mobile epifauna and infauna composition:
    - Crustaceans are among the dominant infaunal and epibenthic invertebrates in the soft sediment habitats of the area
    - Molluscs are scarce comprising only 4% of the total number of individuals and 9% of taxa recorded from infauna samples
    - Echinoderms are scarce comprising only 5% of the total number of individuals and 4% of taxa recorded from infauna samples.

5.3.2.2 BTL and Inter-Field Spur Line Corridor

Sea floor communities in deeper (>100 m) shelf waters receive insufficient light to sustain ecologically sensitive primary producers such as seagrasses, macroalgae or zooxanthellate scleractinian (reef building) corals.

In 2007, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) conducted extensive benthic habitat mapping surveys and epifauna (living on the surface of the sediment) sampling in deep waters (100 m to 1000 m) spanning 13 sites between Barrow Island and Ashmore Reef, running downslope across the continental shelf and continental slope of the North West Shelf (Williams *et al.* 2010). At the continental slope (approximately 400 m water depth), all survey sites predominantly comprised, soft muddy sediment.

Given the depth of water in which the proposed BTL will be situated (>400 m rising to 125 m depth at the tie in point), these benthic primary producer groups will not occur in the BTL corridor.

Given the water depths and similarities in the seabed sediments, benthic communities along the BTL route are expected to be similar to that found at the deeper waters of the Browse Development Area. These are described above and are expected to be similar to those communities that are widespread and well represented along the continental shelf and upper slopes of the North West Shelf region (Brewer *et al*. 2007).

5.3.3 Listed Threatened Ecological Communities

A search of the EPBC Act Protected Matters Database undertaken on 09/08/2018 identified no Listed Threatened Ecological Communities in close vicinity of the Project area.

5.4 Fauna

5.4.1 Protected Species

The North-west Marine Region is an important area for protected species listed under the EPBC Act and/or the WA WC Act. Protected species that may occur in the Project area include seabirds and migratory seabirds, marine mammals, marine reptiles and fish.

A search of the EPBC Act Protected Matters Database was undertaken on 09/08/2018 using the Protected Matters Search Tool (PMST). A 50 km buffer was applied around the Project area for the PMST search. The search identified 25 EPBC Act listed threatened species and 44 listed migratory species (inclusive of the aforementioned listed threatened species) that may occur, or where suitable habitat may occur in or in close vicinity (within 50 km buffer) to the Project area. A search of Western Australian Department of Biodiversity, Conservation and Attractions NatureMap identified a further one species (Spinner dolphin) that is listed under the WA WC Act but not under the EPBC Act. The PMST search identified 87 species listed as marine under the EPBC Act (inclusive of the aforementioned threatened and migratory species) that may occur in the area.

An assessment was made using existing studies, literature and each species. Species Profile and Threats Database (SPRAT) profile on the likelihood of each listed species occurring in the Project area and/or interacting with the Proposed Action. The majority of the species identified in the search were assessed to be either occasional transient visitors to the Project area that are unlikely to occur in significant numbers, species that may fly over the Project area but are unlikely to interact with the Proposed Action; or species whose range and preferred habitat mean that they are highly unlikely to occur in the Project area.

The full list of threatened and migratory species identified in the PMST search, and an outcome of the assessment of likelihood of interaction with the Proposed Action is provided in **Appendix B**. The full PMST report is provided in **Appendix C**.

Table 9 details the protected species that the assessment has identified as being likely to occur in the Project area and/or interact with the Proposed Action. The relevant recovery plan or approved conservation advice; and key threats identified in these documents are also detailed where applicable. Each of these species are discussed further in the following sections.

Table 9 Listed Threatened and Migratory Species that are likely to occur in the Project area or interact with the Proposed Action

Species	Status under EPBC Act	Status under WA WC Act	Recovery plan / conservation advice	Key threats identified in recovery plan / conservation advice
Birds				
Australian Lesser Noddy (*Anous tenuirostris melanops*)	Vulnerable (VU), Marine	Endangered (EN)	Conservation advice *Anous tenuirostris melanops* Australian lesser noddy (Threatened Species Scientific Committee 2015a)	Habitat degradation / modification
White-tailed Tropicbird (*Phaethon lepturus*)	Migratory, Marine	Migratory birds protected under an international agreement (IA)	None	N/A
Red-tailed Tropicbird (*Phaethon rubricauda*)	Migratory, Marine	IA, Priority 4: Rare, Near Threatened and other species in need of monitoring	None	N/A
Little Tern (*Sternula albifrons*)	Migratory, Marine	IA	None	N/A
Marine Mammals				
Pygmy Blue Whale (*Balaenoptera musculus brevicauda*)	EN, Migratory, Marine	EN	Conservation Management Plan for the Blue Whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (Commonwealth of Australia 2015)	Noise interference Vessel disturbance
Humpback Whale (*Megaptera novaeangliae)*	VU, Migratory, Marine	Conservation dependent fauna (CD)	Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale)	Noise interference Vessel disturbance

Species	Status under EPBC Act	Status under WA WC Act	Recovery plan / conservation advice	Key threats identified in recovery plan / conservation advice
			(Threatened Species Scientific Committee 2015b)	
Bryde's Whale (*Balaenoptera edeni*)	Migratory, Marine		None	N/A
Spinner dolphin (*Stenella longirostris*)	Marine	P4	None	N/A
Reptiles				
Green Turtle (*Chelonia mydas)*	VU, Migratory, Marine	VU	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017)	Vessel disturbance Light pollution Acute chemical discharge (oil pollution)
Hawksbill Turtle (*Eretmochelys imbricata)*	VU, Migratory, Marine	VU		
Sharks and Rays				
Whale Shark (*Rhincodon typus*)	VU, Migratory, Marine	Other specially protected fauna (OS)	Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015c)	Vessel disturbance
			Whale shark Rhyncodon typus) recovery plan 2005-2010 (DEH, 2005)	Habitat degradation / modification
Shortfin Mako (*Isurus oxyrinchus*)	Migratory, Marine		None	N/A
Longfin Mako *(Isurus paucus*)	Migratory, Marine		None	N/A

5.4.2 Biologically Important Areas

A review of the National Conservation Values Atlas identified biologically important areas (BIAs) which may overlap spatially or are within the vicinity of the Project area. BIAs are spatially defined areas where aggregations of individuals of a regionally significant species are known to display biologically important behaviours such as breeding, foraging, resting or migration. These BIAs and an assessment of the likelihood that the Proposed Action will interact with them are detailed in **Table 10** and presented in **Figure 6** and **Figure 7**.

Table 10 Biological Important Areas in the Vicinity of the Project area

Species	Species Status	Description	Likelihood of Interaction with Proposed Action
Little Tern (*Sternula albifrons*)	Migratory	Known resting areas on Kimberley, Pilbara and Gascoyne coasts and islands including the sandy clays of Ashmore Reef, Rowley Shoals and Scott Reef.	Potential interaction with installation and support vessels. Browse Development Area intersects BIA. BTL route intersects the BIA near Rowley Shoals.
Wedge-tailed Shearwater (*Ardenna pacifica*)	Migratory	Known foraging and breeding BIAs exist on the Kimberley and northern Pilbara coasts and islands.	Potential interaction with installation and support vessels. BTL route intersects BIA near tie-in point. Browse Development Area >100 km from BIA.
White-tailed Tropicbird (*Phaethon lepturus*)	Migratory	Known breeding and foraging areas at Rowley Shoals and Ashmore Reef.	Potential interaction with installation and support vessels. BTL route intersects the BIA near Rowley Shoals.
Pygmy Blue Whale (*Balaenoptera musculus*)	Endangered, Migratory	The north and south bound pygmy blue whale migration has been tracked repeatedly via underwater noise loggers and satellite tagging of a small number of individuals for the Western Australian population. In the general pygmy blue whales are moving along the shelf break in deep waters (500-1,000 m) and north bound whales have been detected off Exmouth, the Montebello Islands and Scott Reef between April and August (peak pulse in June and July). Pygmy blue whales pass south by the latitude of Scott Reef over late October to late December, with the migration of whales off the Montebello Islands and Exmouth from October to the end of January, peaking in late November to early December (McCauley 2011). The Conservation Management Plan for Blue Whales (Commonwealth of Australia 2015) documents a possible foraging area within the vicinity of the Scott Reef. Within the National Conservation Values Atlas Scott Reef is identified as a foraging area.	Potential interaction with installation and support vessels. The Browse Development Area is within the pygmy blue whale migratory path (defined as a BIA within the National Conservation Values Atlas). The Conservation Management Plan for the Blue Whale identifies parts of the Browse Development Area as a possible foraging area for pygmy blue whales.
Humpback Whale	Vulnerable, Migratory	The west coast humpback whale population (Breeding Stock D) migrate between summer feeding grounds in	Very low. FPSOs and subsea infrastructure >180 km away from BIA.

Species	Species Status	Description	Likelihood of Interaction with Proposed Action
(*Megaptera novaeangliae*)		Southern Ocean and tropical breeding and calving grounds off northern Western Australia. Known migration north follows a route along the edge of the continental shelf passing to the west of Barrow and the Montebello Islands from June to September (peaking in late July). The southern migration follows a relatively narrow track between Dampier Archipelago and the Montebellos with Exmouth Gulf and Shark Bay key resting areas. The south-bound migration occurs from August to November (peaking in September-October). With reference to the Browse Development area, a large majority of both north- and southbound humpback whales appear to remain landward of the 100 m isobath along the Kimberley coast (including the Dampier Peninsula). The area north of the Lacepede Islands to Camden Sound is the known calving and nursing area. Observations of large number of humpback whale calves along the North West Cape has identified the calving ground may extend from Camden Sound to as far south as North West Cape (Irvine *et al*. 2018). Humpback whales can occur in the vicinity of Scott Reef at any time during the migration seasons but is limited to low numbers and does not represent a significant proportion of the population.	BTL route located outside of BIA (~35 km distance at closest point).
Green Turtle *(Chelonia mydas)*	Vulnerable, Migratory	Scott Reef is a known nesting area, with inter-nesting areas just offshore in waters 4-15 m deep (Commonwealth of Australia 2017).	Potential interaction with installation and support vessels. The Browse Development Area is located within the BIA.
Hawksbill Turtle (*Eretmochelys imbricata*)	Vulnerable, Migratory	Scott Reef is a known nesting area, with inter-nesting areas just offshore in waters 4-15 m deep (Commonwealth of Australia 2017).	Potential interaction with installation and support vessels. The Browse Development Area is located within the BIA.
Whale Shark (*Rhincodon typus*)	Vulnerable, Migratory	Known foraging area. Satellite tracking indicates that whale sharks travel northward along the 200m isobath (Commonwealth of Australia 2017).	Very low. Browse Development Area and BTL route located outside of BIA (~40 at closest point).

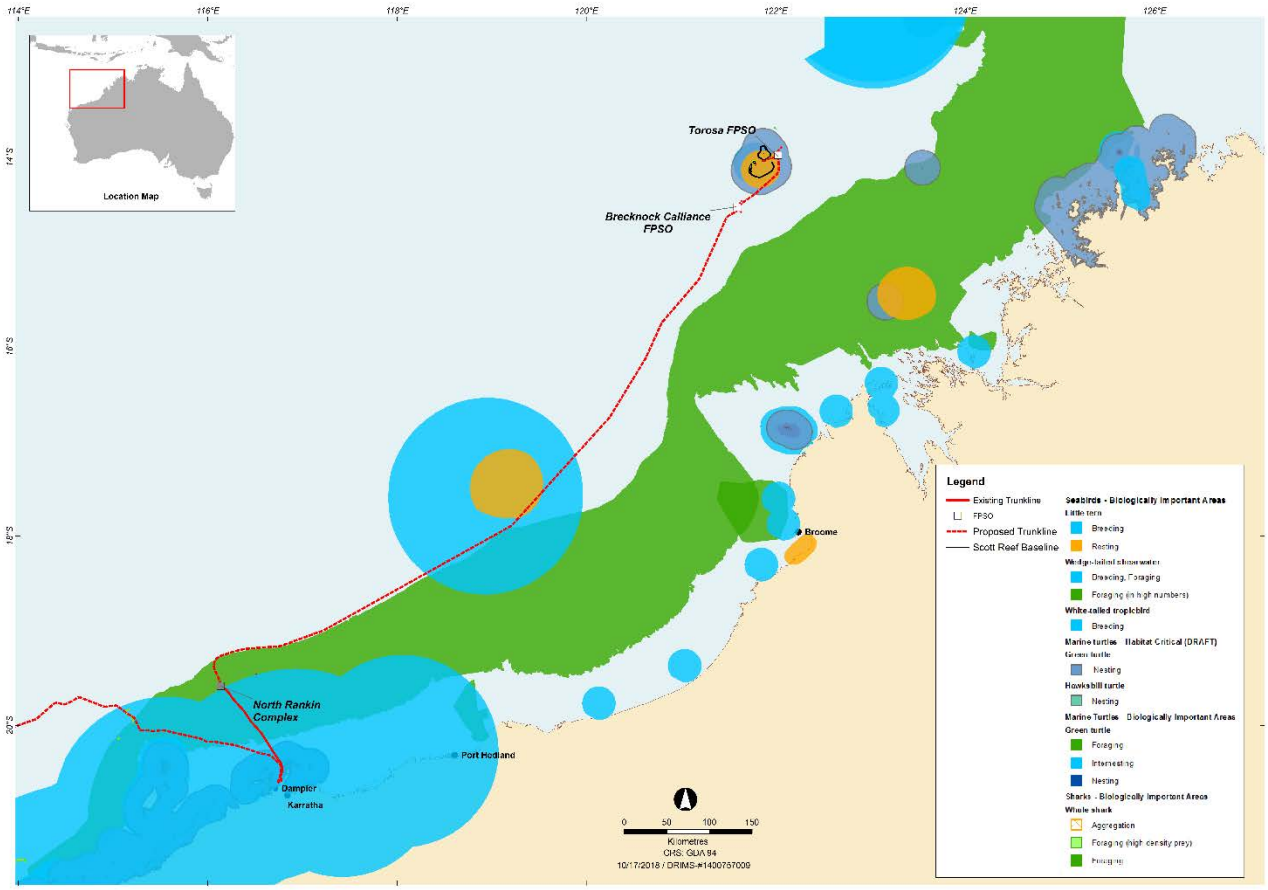

Figure 6 Biological Important Areas (BIAs) for selected species

5.4.3 Seabirds and Migratory Shorebirds

5.4.3.1 Seabirds

Seabirds include pelagic and coastal species that will generally forage offshore and spend considerable periods at sea. Non-breeding birds will generally only gather outside the breeding season in areas where prey species are densely aggregated. Seabirds nest in colonies, which can vary in size from a few dozen birds to millions. Many species undertake annual migrations of thousands of kilometres. The seabird fauna for the North-west Marine Region consists of tropical and sub-tropical breeding species and non-breeding migrants. Surveys undertaken in the Browse Basin (including Scott Reef) in 2008 (Sutton *et al*, 2018) identified at least 23 species of seabird

Many species of seabirds will undertake annual migrations over thousands of kilometres. Due to the broad geographical ranges of seabirds, many of the species in the Region have the potential to occur in the Project area.

Seabirds around Scott Reef are predominately associated with Sandy Islet, and occur in small numbers in comparison to other breeding and roosting sites in the region. Seabird surveys conducted at Scott Reef observed greater numbers of birds during spring than winter (Jenner *et al*. 2009). Crested terns, brown boobies and common noddies are among the dominant species (Jenner *et al*. 2009; Smith *et al*. 2004; WAM 2009). Scott Reef and the surrounding waters have been identified as Biologically Important Areas (BIAs) for little terns. There is no evidence of nesting at Sandy Islet for any seabird species.

Rowley Shoals supports a wide range of seabirds including Western Australia's second largest breeding colony of red-tailed tropicbird (P4, IA) (DEC 2007). Rowley Shoals and the surrounding waters have been identified as BIAs for white-tailed tropicbirds and little terns.

The following protected seabird species are likely to occur in the Project area and/or interact with the Proposed Action (refer to Appendix B for full list of species identified in PMST search):

- *Australian Lesser Noddy*: Listed vulnerable and marine under the EPBC Act and Endangered under the WA WC Act. The Australian lesser noddy is usually only found around its breeding islands in the Houtman Abrolhos Islands and possibly on Ashmore Reef in WA (Storr *et al*. 1986). The Australian lesser noddy usually occupies coral-limestone islands that are densely fringed with white *mangrove Avicennia marina* and occasionally occurs on shingle or sandy beaches (Higgins & Davies 1996). The Australian lesser noddy may forage well out to sea (Johnstone & Storr 1998; Storr *et al*. 1986) or in seas close to breeding islands and fringing reefs (Storr *et al*. 1986; Whittell 1942). Approximately 200 individuals were recorded at Scott Reef by Smith *et al*. 2004.
- *White-tailed Tropicbird*: Listed marine and migratory under the EPBC Act and Migratory under the WA WC Act. White-tailed Tropicbird occupies marine habitats in tropical waters. They breed on islands and atolls, where it nests in a variety of habitats including on bare sandy ground. White-tailed tropicbirds are known to breed at Rowley Shoals which are located over 25 km from the pipeline route. They feed mostly on fish and squid and captures most of its food by deep-plunging vertically through the water column to depths of 20 m. The BTL route intersects an identified BIA at Rowley Shoals which is a known foraging area (DoEE 2018a).
- *Red-tailed Tropicbird*: Listed marine and migratory under the EPBC Act and Migratory and Priority 4 under the WA WC Act. They breed on islands and atolls, where it nests in a variety of habitats including on bare sandy ground. Red-tails tropicbirds are known to breed at Rowley Shoals which are located over 25 km from the BTL route. They display similar feeding behaviours as the White-tailed Tropicbird (DoEE 2018b).

- *Little Tern:* Listed marine and migratory under the EPBC Act and Migratory under the WA WC Act. The little tern is a coastal seabird which usually forages in very shallow water, more often in brackish lagoons and saltmarsh creeks (Birdlife Australia 2013). The species is widespread in Australia, with breeding sites widely distributed from north western WA, around the northern and eastern Australian coasts to south-eastern Australia. The species is known to breed on barren or sparsely vegetated beaches located on seashores, islands, estuaries and offshore coral reefs. Approximately 500 individuals were recorded at Scott Reef by Smith *et al*. 2004 and BIAs (known resting areas) for the species have been identified at both Scott Reef and Rowley Shoals.

5.4.3.2 **Migratory Shorebirds**

Migratory shorebirds are generally associated with wetland or coastal environments as these habitat types are important for feeding, nesting and/or migratory stopovers. Many shorebird species undergo annual migrations, typically breeding at high latitudes of the northern hemisphere and migrating south for the non-breeding period. The North-west Marine Region contains major routes and key wintering sites for migratory shorebirds for the East Asian-Australasian Flyway (EAAF). In coastal environments, shorebirds generally feed during low tide on exposed intertidal mudflats and find areas in which to roost at high tide.

The North-west Marine Region contains a number of potential flight paths for migratory shorebirds and important migratory shorebird sites including Ashmore Reef (over 200 km to the north of the Project area) which is recognised as an internationally important site for five species.

Due to the large geographical ranges of migratory shorebirds, many of the species in the North-west Marine Region have the potential to pass through the Project area. The Project area overlaps with the migratory shorebird corridor and as such shorebird presence will be transitory and seasonal. Migratory shorebirds are occasionally observed in very low numbers at Scott Reef, and Sandy Islet may be used as a resting point during the migration between the northern hemisphere and Australia. However, given its small size, Sandy Islet is unlikely to support large numbers of migratory shorebirds.

Rowley Shoals, in particular Bedwell and Cunningham Islands (Clerk and Imperiuse, respectively) are believed to be important resting places for migratory shorebirds with large flocks of unidentified waders being recorded (DEC 2007).

Threatened and migratory shorebirds were identified by the search of the EPBC Act Protected Matters database as potentially occurring in, or migrating through, the Project area. Further assessment indicates that none of these migratory shorebird species are likely to occur in the Project area in significant numbers and/or interact with the Proposed Action.

5.4.4 Marine Mammals

Marine mammals have wide distributions that are associated primarily with seasonal feeding and migration patterns that are linked to their reproductive cycles. Twenty-seven cetacean species are known to occur in the North-west Marine Region and all are protected under Commonwealth and WA State legislation.

Various studies on marine mammals have been used to characterise the abundance and distribution of marine mammals within the Project area and the broader region. These studies include:

- Surveys to support habitat associations of cetaceans and seabirds in the Tropical Eastern Indian Ocean undertaken during winter and spring 2008 (Sutton *et al*, 2018).
- Long-term sea noise logger deployments within and around Scott Reef (data presented from September 2006 to July 2009) (McCauley 2011).
- Vessel surveys in the Scott Reef/Browse Basin during winter 2008 (Jenner *et al*. 2009).
- Aerial and vessel surveys for humpback whales in the nearshore south-west Kimberley during winter 2008 (Jenner & Jenner 2009a, 2009b).

- Aerial and vessel surveys for humpback whales and other cetaceans along the Kimberley coast and out to Scott Reef in 2008, 2009 and 2010 (Jenner & Jenner 2010; RPS 2010a, 2010b, 2011a, 2011b).
- Satellite tagging program of humpback whales on their southward migration passing the Dampier Peninsula in 2009 and northward migration passing the North West Cape in 2011 (Double *et al*. 2010, 2012) (**Figure 8**).

These studies, together with each species' SPRAT profile have been used to assess the likelihood of occurrence and/or interaction of each species with the Proposed Action. The outcome of this assessment is provided in Appendix B, with the majority of the marine mammal species assessed as infrequent transient visitors to the Project area that are unlikely to occur in significant numbers. Those marine mammal species that are likely to occur in the Project area or interact with the Proposed Action are described below.

- *Blue Whale / Pygmy Blue Whale*: Listed Endangered, migratory and marine under the EPBC Act and Endangered under the WA WC Act. Blue whales are the largest living animal and can grow to a length of over 30 m and weigh an average of 100 to 120 tonnes. There are two recognised sub-species in Australia; the 'true' blue whale (*Balaenoptera musculus intermedia*) and the 'pygmy' blue whale (*Balaenoptera musculus brevicauda*) (DOEE 2018c).

  Acoustic detections suggest that true blue whales migrating north occur overwinter and there are recorded feeding aggregations around the Perth Canyon well south of the Project area, migrations continues northwards in waters over 500-1000 m depth once past North West Cape with animals going to warm tropical waters in the Western Indian Ocean and Indonesia to breed and then migrating south in mid-October (McCauley *et al*. 2004). There is a proportion of the population of pygmy blue whales that will transit during migration within and adjacent to the Browse Development Area. There have been sighting of feeding pygmy blue whales within the Browse Development area. Woodside has over three years of data from various noise loggers deployed within the Project area and both near and inside Scott Reef. The logger data suggest that the majority of pygmy blue whales travel in deep water, passing to the west of Scott Reef, with a relatively small proportion passing in close proximity to the Project area and Scott Reef (McCauley 2011). This is supported by published data from satellite tracking of pygmy blue whales during 2009 and 2011, five of which were tracked travelling north of North West Cape, with the closest individual passing Scott Reef to the west at a distance of approximately 100 km (**Figure 7**) (Double *et al*. 2014).

  North-bound animals have been detected on noise loggers to pass Scott Reef over a period of 135 days between early-April and mid-August, peaking between mid-May and mid-June (McCauley 2009, 2011). Pygmy blue whales travel south past the latitude of Scott Reef from late October to late December, with most individuals passing over a period of approximately 50 days between late-October and late-December.

  Noise loggers deployed between North and South Scott Reef and West of South Scott Reef detected vocalising pygmy blue whales on 25 occasions between September 2009 and June 2009. Nineteen of the whale calls detected in the channel were also detected by the logger listening to the west of Scott Reef, implying the animals had swum through the channel. A logger listening to the west of the reef detected pygmy blue whales on 39 occasions over the same period, many of these involving animals passing close to the reef edge. Noise loggers positioned inside the lagoon of South Scott Reef between June 2007 and September 2008 did not record any vocalising pygmy blue whale calls, suggesting that no individuals entered the reef lagoon system over that period (McCauley 2011).

Surveys undertaken in 2008 encountered two pygmy blue whales near the eastern entrance of Scott Reef channel. These swam through the channel prior to exiting at the western entrance. Three additional individuals were then observed at the western entrance (Sutton *et al*, 2018). Sutton *et al* (2018) noted that encounters of pygmy blue whales occurred at times of elevated biomass at Scott Reef, although direct feeding on krill by pygmy whales was not observed. They also noted that if feeding was occurring at what is a potentially regular and reliable foraging ground, pygmy blue whales may use the area to replenish energy stores in the preparation for the journey back to higher latitudes.

Data collected from vessel and aerial surveys in the vicinity of the Project area and Scott Reef suggested numbers of whales occurring in the area are consistent with the noise logger data (Jenner *et al*. 2009).

Examination of the evidence and interpretation of the data from the various studies and surveys conducted over the years, including most recent data from satellite tracking of whale movements, and information on movement and behaviour of pygmy blue whales collected from known feeding areas such as Perth Canyon, suggests that Scott Reef may be utilised for foraging by a proportion of the pygmy blue whale population during their passage between regular feeding grounds in the south and breeding grounds to the north.

The migratory paths of pygmy blue whales pass to the west of the BTL route.

- *Humpback Whales*: Listed vulnerable, migratory and marine under the EPBC Act and Conservation Dependent under the WA WC Act. Humpback whales are moderately large baleen whales, with a maximum recorded length of 17.4 m and an average weight of 25 to 30 tonnes (DoEE 2018d). They occur throughout Australian waters, their distribution being influenced by migratory pathways and aggregation areas for resting, breeding and calving.

  The annual migration from the summer feeding grounds in Antarctica occurs between May and October, with breeding and calving taking place in the vicinity of Camden Sound (approximately 300 km east of the Project area) between mid-August and early September. The southern migration peaks at the end of September, with females with calves the last to leave the breeding grounds (RPS 2010a). Exmouth Gulf and Shark Bay are regular resting locations en route to Antarctica. The majority of both north and south-bound humpback whales appear to remain landward of the 100 m isobath and they have not been commonly observed in deeper waters to the west. **Figure 8** shows a conceptual understanding of humpback whale migration paths development from Jenner *et al*. (2001) and RPS (2010b).

  The Project area, including the entire BTL route, is located towards the outer edge of the main humpback whale migration corridor, and humpback whales are therefore expected to only occasionally transit through this area. RPS 2010a, 2011a observed that the highest density of sightings occurred between 15 and 35 km from the coast in water shallower than 50 m. This is further supported by data from noise loggers in the vicinity of Scott Reef that have detected humpback whales in low numbers, both inside and outside the reef, from late June to mid-October (2006-2009) (McCauley 2011). Aerial surveys conducted at Scott Reef over the migration season in 2009 and 2010 also observed low numbers of humpback whales in the vicinity of the reef (14 and 11 individuals respectively) (RPS 2010b, 2011b). The low occurrence of humpback whales at Scott Reef in 2009 and 2010 is consistent with observations from previous surveys (Jenner *et al*. 2009; Jenner & Jenner 2008). It is not known whether particular whales show fidelity to Scott Reef or what other factors influence whales to visit the reef.

- *Bryde's Whale:* Listed as migratory and marine under the EPBC Act. Bryde's whales are distributed widely throughout tropical and sub-tropical waters (DOEE 2018e). In 2008, Jenner *et al*. (2009) recorded Bryde's whales in low numbers across a large survey area between the mainland and Scott Reef. RPS (2010c) recorded one Bryde's whale, 10 km west of Coulomb Point on the Kimberley coast, during aerial and vessel surveys in 2009. Calls attributed to Bryde's whales have been recorded year round in low numbers on sea noise loggers deployed inside and outside of Scott Reef between September 2006 and June 2009 (McCauley 2011). Bryde's whales are likely to occur in low numbers along the BTL route.
- *Spinner Dolphin:* Listed as marine under the EPBC Act and listed as Priority 4 under the WA WC Act. Spinner dolphins are found in tropical, subtropical and, occasionally warm temperate waters. Spinner dolphins were the most commonly encountered small cetacean during aerial and vessel surveys at Scott Reef, in a variety of water depths (RPS 2011c). Surveys undertaken in 2008 (Sutton *et al.* 2018) frequently recorded spinner dolphins near Scott Reef.

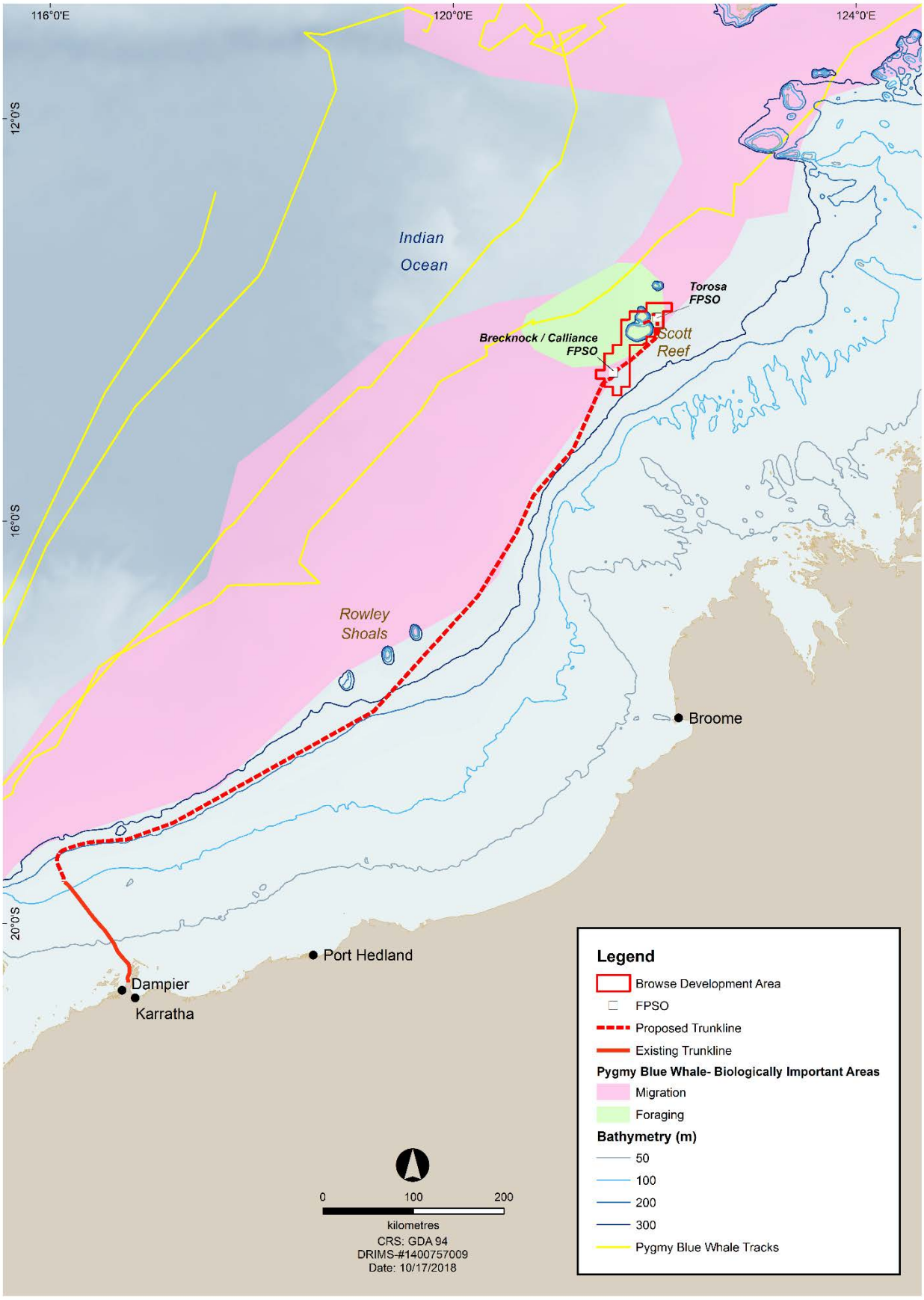

Figure 7 Satellite Tracks of Pygmy Blue Whale Migration Pathways and BIAs (Double *et al* 2014)

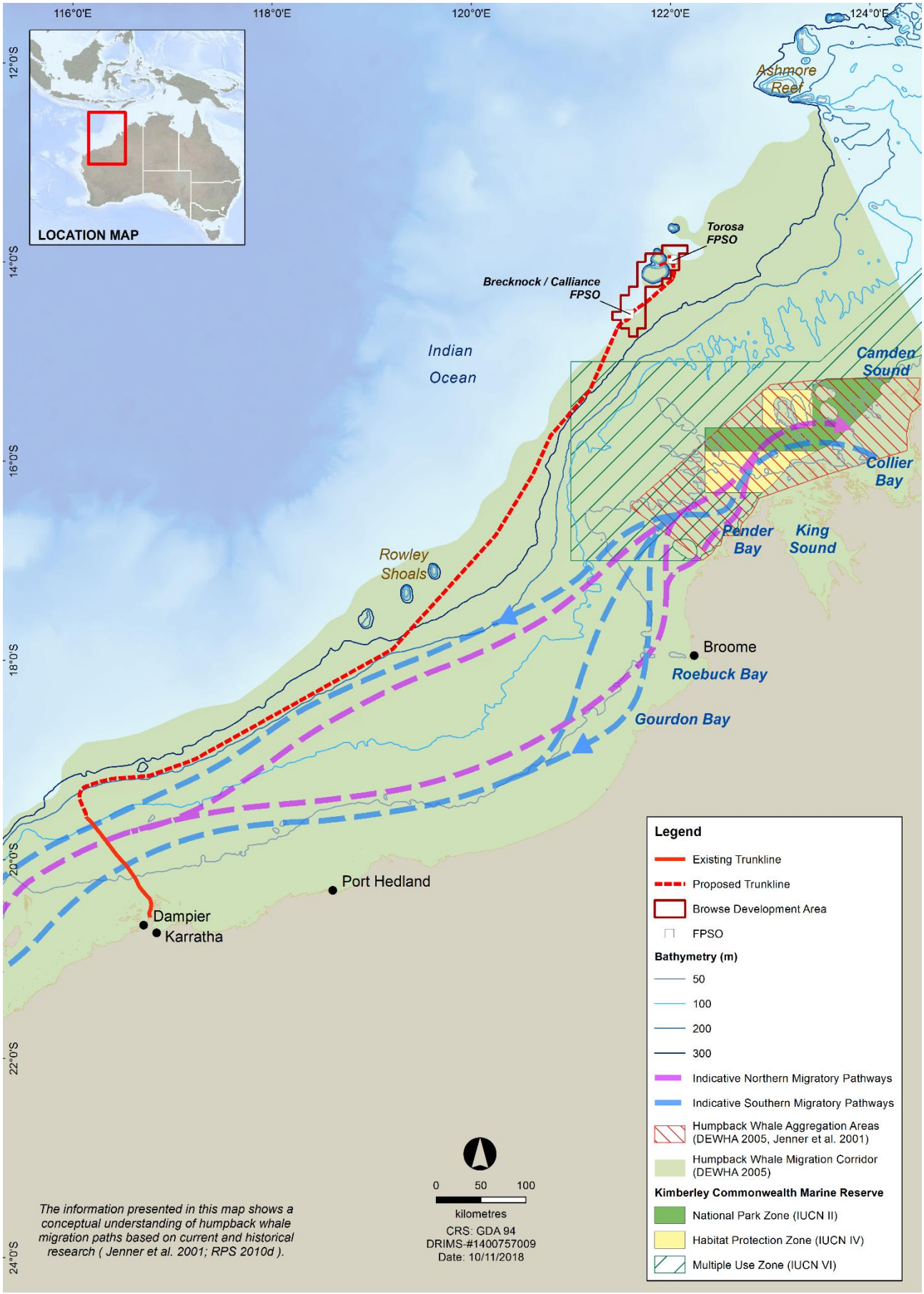

Figure 8 Humpback Whale Migratory Routes (Developed from Jenner *et al*. 2001; RPS 2010b)

5.4.5 Fish

The North-west Marine Region contains a diverse range of fish of tropical Indo-west Pacific affinity (Allen *et al*. 1988). The North-west Marine Region is characterised by the highest level of endemism and species diversity compared to the remaining areas of the Australian continental slope. The continental slope of the Timor Province and the North-west Transition supports more than 418 and 505 species of demersal fish respectively, of which 64 are considered to be endemic which is the second richest area for demersal fish species across the entire Australian continental slope (Last *et al*., 2005). The demersal slope fish assemblages of the North-west Marine Region have been identified as a KEF within the North-west Marine Region (Commonwealth of Australia 2012). Scott Reef and its environs support a diverse fish assemblage in both shallow and deeper waters.

The PMST search identified seven threatened fish species (of which four are also migratory) plus an additional five migratory that are not considered threated where either the species or the species habitat may occur. The PMST search also identified 40 seahorse and pipefish (are listed as 'marine'), which are likely to be present within the Project area. Based on available existing information including a number of previous field studies and SPRAT profiles, the fish species that are likely to occur in the Project area or interact with the Proposed Action include:

- *Whale Shark:* Listed vulnerable, migratory and marine under the EPBC Act and 'other specially protected fauna' Endangered under the WA WC Act. Whale sharks occur in both tropical and temperate waters (Colman 1997). There is a general lack of knowledge on many aspects of whale shark biology, including definitive migration patterns. They are normally oceanic and cosmopolitan in their distribution and are known to aggregate in the reef front waters adjacent to the Ningaloo Reef, which is over 300 km to the south of the BTL tie in point and over 1,000 km to the south of the Browse Development Area (Colman 1997; Wilson *et al*. 2006).

  Preliminary research on the migration patterns of whale sharks in the western Indian Ocean, and isolated and infrequent observations of individuals, indicate that a small number of the whale shark population migrate through the wider Browse region (Jenner *et al*. 2009; Meekan and Radford 2010; McKinnon *et al*. 2002; Wilson *et al*. 2006). Tagging and tracking of whale sharks, indicates that individuals may occasionally pass by within the vicinity of Scott Reef.

- *Shortfin Mako Shark:* Listed migratory and marine under the EPBC Act. The shortfin mako shark is found in tropical and warm-temperate seas in water depths up to 500 m (Cailliet *et al*. 2009). The shortfin mako is a wide-ranging oceanic shark widespread in Australian waters and is likely to occur in the Project area.

- *Longfin Mako Shark:* Listed migratory and marine under the EPBC Act. The longfin mako is a widely distributed oceanic tropical shark, but rarely encountered. In Australian waters, it is found from Geraldton in WA, north to Port Stephens in New South Wales and is likely to occur in the Project area.

5.4.6 Marine Reptiles

5.4.6.1 Marine Turtles

Marine turtles are long-lived and may take between 20 and 50 years to reach sexual maturity (Miller 1997). They have similar life cycle characteristics, which include migration from foraging areas to mating and nesting areas. With the exception of flatback turtles, all species have an oceanic pelagic stage before they move into coastal or nearshore waters to begin the breeding cycles. Habitat-use varies and is dependent on the stage of the life cycle. The Kimberley region is considered to be significant for turtles, supporting large feeding and nesting populations of green, flatback, hawksbill and loggerhead turtles (Limpus 2007, 2008, 2009; Pendoley 2005; RPS 2010b).

The PMST search (refer to **Appendix B**) identified three endangered/migratory and three vulnerable/migratory marine turtle species where foraging, feeding or related behaviour is known or likely to occur in the Project area.

Woodside on behalf of the BJV has supported marine turtle studies (particularly green turtles at Scott Reef) including nesting surveys at Scott Reef, in water surveys and satellite tagging (**Figure 9**). These studies, recorded sightings and each species SPRAT profile have been used to assess the likelihood of occurrence and/or interaction of each species with the Proposed Action. The outcome of this assessment is provided in Appendix B, with the majority of the marine turtle species assessed as infrequent transient visitors to the Project area that are unlikely to occur in significant numbers. Those marine turtles that are likely to occur in the Project area or interact with the Proposed Action are described below.

- *Green turtle:* Listed vulnerable, migratory and marine under the EPBC Act and 'vulnerable' under the WA WC Act. Green turtles are distributed globally throughout tropical and sub-tropical waters, with WA supporting one of the largest green turtle populations in the world (Limpus 2004). Green turtles forage in shallow benthic habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds, feeding on seagrass beds or algae mats (DOEE 2018f).

  Sandy Inlet at Scott Reef is a known green turtle nesting site. There is currently insufficient data to estimate population abundance of nesting green turtles at Scott Reef, however, preliminary data from tagging and mark/recapture of individuals suggests that the population is not large compared to the Lacepede Islands and other rookeries in WA (Guinea 2009, 2010). Green turtles nesting on Sandy Islet have an estimated 20 km inter-nesting buffer (Commonwealth of Australia 2017), located primarily to the south and west of Sandy Islet over sandy substrates, with a sand patch at the southern end of Sandy Islet Reef appearing to function as an inter-nesting area of some significance (Guinea 2009, 2010). This nesting and inter-nesting area has identified as a BIA and as habitat critical to the survival of green turtles in the DoEE's Recovery Plan for Marine Turtles 2017-2027 (Commonwealth of Australia, 2017).

  Satellite tracking of 12 individuals found the majority of the tagged turtles to stay within 3 km of Sandy Islet during inter-nesting, although two individuals travelled approximately 15 km south to the lagoon edge of South Scott Reef (Guinea 2011).

- *Hawksbill turtle:* Listed vulnerable and migratory under the EPBC Act and 'vulnerable' under the WA WC Act. Hawksbill turtles are found in tropical, sub-tropical and temperate waters, with nesting mainly confined to tropical beaches (Limpus & Miller 2008). Australia has the largest breeding population of hawksbill turtles in the world, and the largest rookeries (Limpus 2008). Only one individual hawksbill turtle has been recorded nesting at Sandy Islet over four years of monitoring (Guinea 2010). Sandy inlet (nesting) and a 20 km inter-nesting buffer have been identified as a BIA for this species.

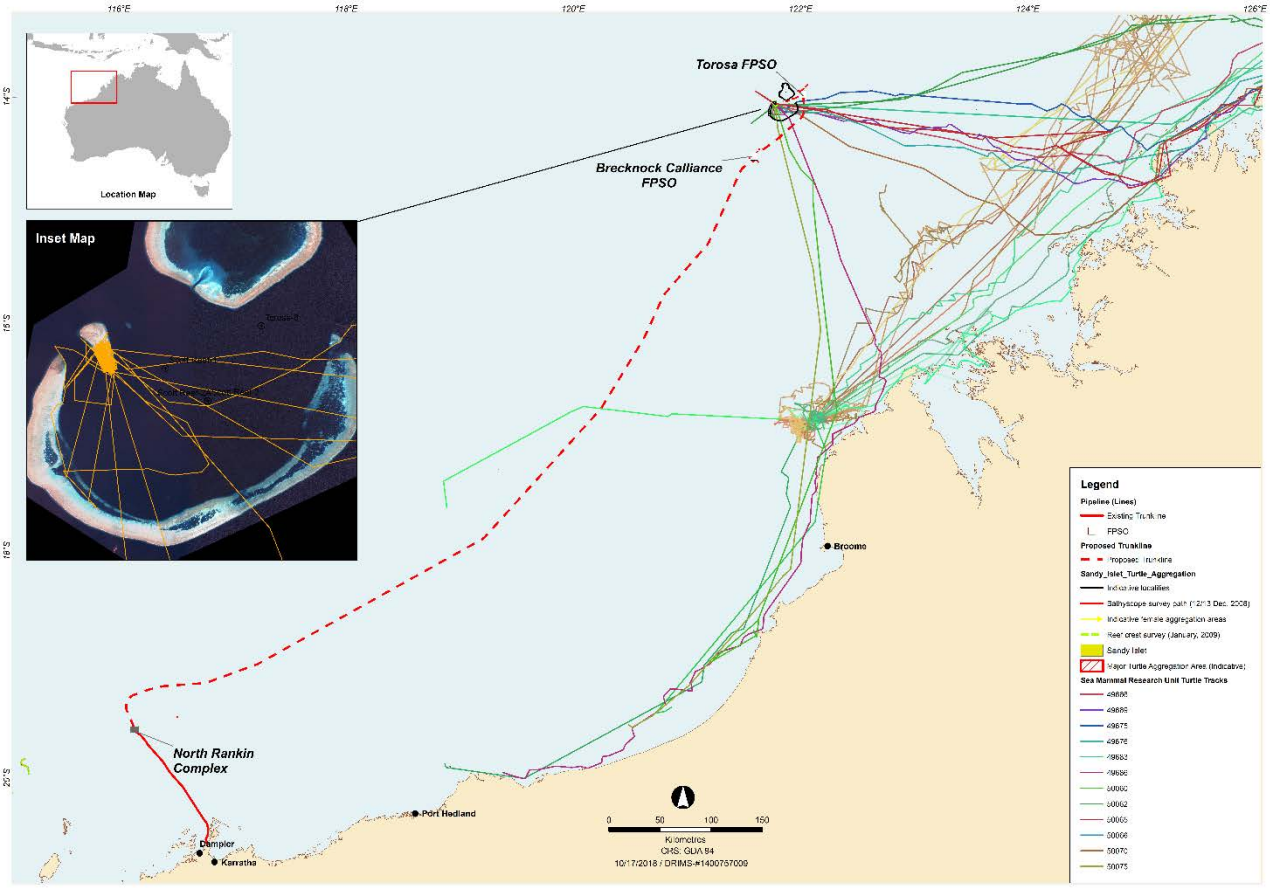

Figure 9 Marine Turtle Tracks

5.4.6.2 **Sea Snakes**

Sea snakes are abundant throughout the shallow seas and inshore waters of tropical Australia, and 20 species are reported to occur in the North-west Marine Region (Wilson & Swan 2003). They occur widely from coral reefs to turbid inshore waters and estuaries, but there are few species known from the region that inhabit deep-water, oceanic environments.

Six species of a sea snake were recorded at Scott Reef in 1973 with four of these species recorded in 2002. Lukoschek *et al* (2013) found that there has been sustained declines in the abundance and diversity of sea snakes at nearby Ashmore reef, and while sea snakes have been less well studied at the other Timor reefs (including Scott Reef), there is evidence of similar declines at these reefs.

Sea snakes are not commonly observed at Rowley Shoals with Berry (1986) noting that no recorded sightings had been made and Udyawer *et al* (2016) highlighting the lack of lack of data on mid-shelf shoals including Rowley Shoals.

While the PMST search identified one threatened species of sea snake (short-nosed sea snake) as having suitable habitat in the area, comprehensive surveys of sea snakes at Scott Reef in February, September and November 2006 did not observe the short-nosed sea snake (URS 2006, 2007a). As such, the species is not considered likely to occur in the Project area in significant numbers.

5.5 Key Ecological Features

Key Ecological Features (KEFs) are elements of the Commonwealth marine environment that are considered to be of regional importance for either a region's biodiversity or its ecosystem function and integrity. The following criteria are used to identify KEFs in the region (Commonwealth of Australia 2017):

- A species, group of species or community with a regionally important ecological role (e.g. a predator, prey that affects a large biomass or number of other marine species)
- A species, group of species or community that is nationally or regionally important for biodiversity
- An area or habitat that is nationally or regionally important for:
    - enhanced or high biological productivity
    - aggregations of marine life
    - biodiversity or endemism
- A unique seafloor feature with ecological properties of regional significance.

A summary of the KEFs located in the North West Marine Region and their distance from the Project area is provided in **Table 11** and **Figure 10**.

Table 11 Summary of Key Ecological Features in the North West Marine Region (Commonwealth of Australia 2017)

Feature	Values	Description	Distance from Development
Continental slope demersal fish communities	High levels of endemism.	The diversity of demersal fish assemblages on the continental slope in the Timor Province, the North-west Transition and the North-west Province is high compared to elsewhere along the continental slope.	Within the Browse Development Area. The BTL corridor traverses the KEF for approximately 250 km.
Seringapatam Reef and Commonwealth waters in the Scott Reef complex	High productivity and aggregations of marine life.	Seringapatam Reef and the Commonwealth waters in the Scott Reef complex are regionally important as they support diverse aggregations of marine life, high primary productivity and high species richness.	Within the Browse Development Area.
Ancient coastline at 125 m depth contour	Unique seafloor feature with ecological properties of regional significance.	Parts of the ancient coastline, particularly where it exists as a rocky escarpment, are thought to provide biologically important habitats in areas otherwise dominated by soft sediments.	>40 km from Browse Development Area. The BTL corridor traverses the KEF for approximately 15 km near the NRC tie-in point.
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	High productivity and aggregations of marine life.	Mermaid Reef and the Commonwealth waters surrounding the Rowley Shoals are recognised as areas of enhanced productivity and high species richness, facilitated by the breaking of internal waves in the waters surrounding the reefs. This results in the mixing and re-suspension of nutrients from water depths of 500 to 700 m into the photic zone. Migratory pelagic species are present due to the steep changes in slope, such as dolphins, tuna, billfish and sharks.	325 km from the facilities and subsea infrastructure. The BTL route runs parallel to this KEF with the shortest distance between the BTL route and the KEF being over 5 km.
Glomar Shoals	High productivity and aggregations of marine life.	The Glomar Shoals are regionally important for their high biological diversity and high localised productivity. Evidence suggests that the shoals support a high abundance of fish.	>740 km from the facilities and subsea infrastructure. >41 km from nearest point of the BTL route.
Canyons linking the Argo Abyssal Plain and Scott Plateau	High productivity and aggregations of marine life.	The canyons linking the Argo Abyssal Plain and Scott Plateau are important features likely to be associated with aggregations of marine life.	>180 km from the facilities and subsea infrastructure. >180 km from nearest point of the BTL route.

Feature	Values	Description	Distance from Development
Exmouth Plateau	Unique seafloor feature with ecological properties of regional significance.	The Exmouth Plateau is a regionally and nationally unique deep-sea plateau in tropical waters. This large topographical features may contribute to the upwelling of deeper water nutrients closer to the surface.	>920 km from the facilities and subsea infrastructure. >200 km from nearest point of the BTL route.
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	High productivity and aggregations of marine life.	Ashmore Reef and Cartier Island and surrounding Commonwealth waters are regionally important for feeding and breeding aggregations of bird and other marine life. They are all areas of enhanced primary productivity in an otherwise low-nutrient environment. Ashmore Reef also supports the highest number of coral species of any reef off the WA coast.	230 km from the facilities and subsea infrastructure. >230 km from nearest point of the BTL route.
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	Unique seafloor features with ecological properties of regional significance.	Aggregations of whale sharks, manta rays, sea snakes, sharks, large predatory fish and seabirds are known to occur in this area associated with the nutrient rich water interacting with the Leeuwin Current.	>820 km from the facilities and subsea infrastructure. >270 km from nearest point of the BTL route.
Carbonate bank and terrace system of the Sahul Shelf	Unique seafloor feature with ecological properties of regional significance.	Know to support a high diversity of organisms and know foraging areas of loggerhead, olive ridley and flatback turtles.	>340 km from the facilities and subsea infrastructure. >340 km from nearest point of the BTL route.
Pinnacles of the Bonaparte Basin	Unique seafloor feature with ecological properties of regional significance.	The Pinnacles of the Bonaparte Basis are likely to support a high number of species as they provide a hard substrate in an otherwise featureless environment.	>580 km from the facilities and subsea infrastructure. >580 km from nearest point of the BTL route.
Commonwealth waters adjacent to Ningaloo Reef	High productivity and aggregations of marine life.	Areas of enhanced productivity adjacent to Ningaloo Reef, resulting in aggregations of whale sharks, manta rays, humpback whales, sea snakes, sharks, large predatory fish and seabirds.	>1,150 km from the facilities and subsea infrastructure. >330 km from nearest point of the BTL route.

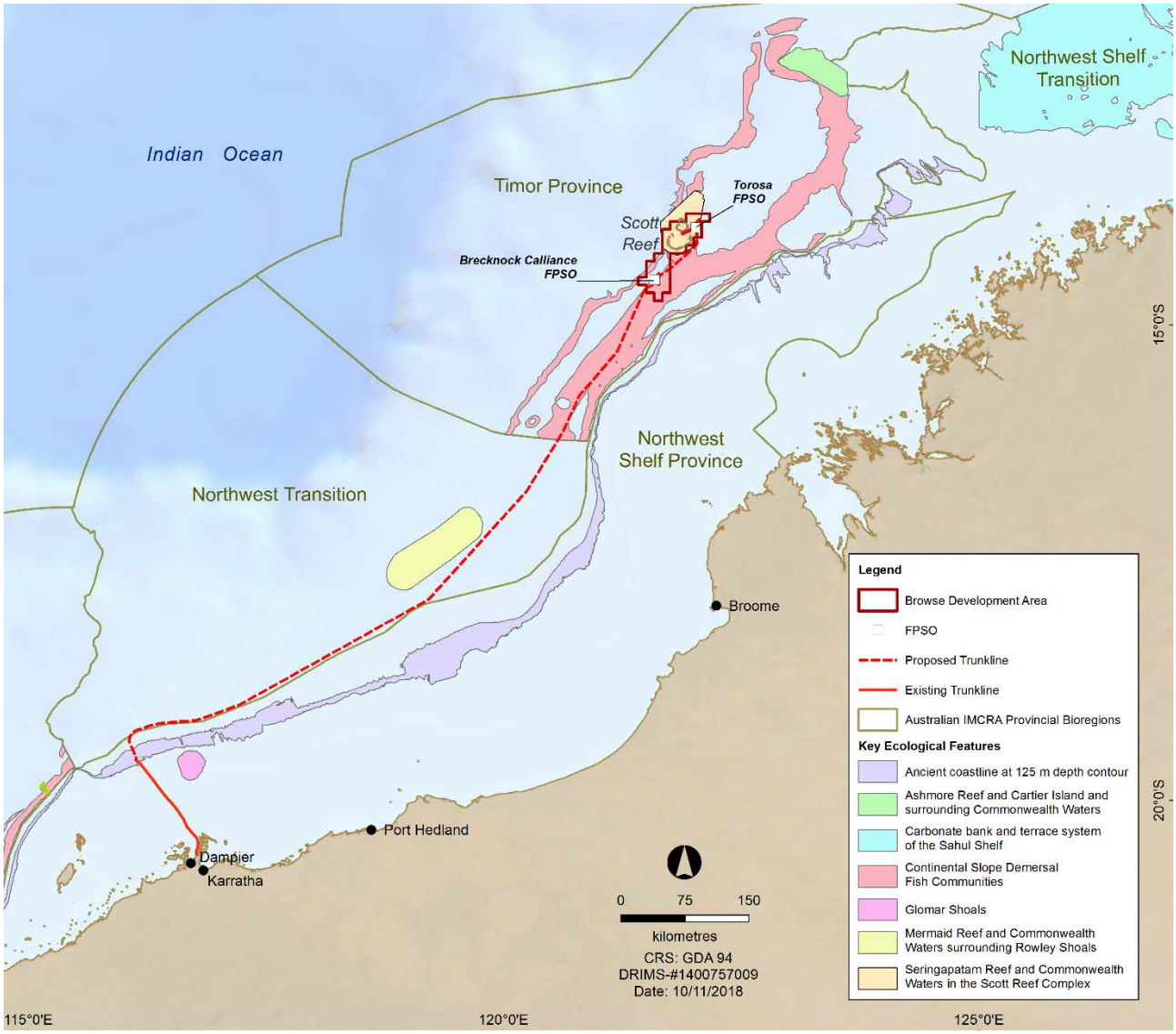

Figure 10 Key Ecological Features

5.6 Protected Places

5.6.1 World Heritage Properties

The PMST identified no World Heritage Properties as occurring in close proximity to the Project area.

5.6.2 National Heritage Places

The PMST identified no National Heritage Places as occurring in close proximity to the Project area.

5.6.3 Commonwealth Heritage List

The Commonwealth Heritage List (CHL) is a list of natural, indigenous and historic heritage places owned or controlled by the Australian Government. Places listed on the CHL are protected under the EPBC Act, as part of the environment of a Commonwealth Marine Area.

The PMST identified the following Commonwealth Heritage Places as occurring in close proximity to the Project area:

- Mermaid Reef - Rowley Shoals
- Scott Reef and Surrounds - Commonwealth Area
- Seringapatam Reef and Surrounds.

Each of these places has been described in **Section 5.2** and **Section 5.3**.

5.6.4 Australian Marine Parks

A network of Marine Parks has been proclaimed around Australia as part of a National Representative System of Marine Protected Areas (NRSMPA). The North-west Marine Region includes 13 Australian Marine Parks forming the North-west Network.

Management plans for these marine reserves have been developed as part of the Australian Government's Commonwealth Marine Reserves Review. The Director of National Parks invited feedback on draft management plans between 21 July and 20 September 2017. The plans were approved by the Minister for the Environment early 2018 and came into effect from 1 July 2018. **Table 12** details the Australian Marine Parks in the vicinity of the Project area including their conservation values. **Figure 11** shows the Australian Marine Parks in the vicinity of the Project area.

Table 12 Australian Marine Parks in the Vicinity of the Project area (Commonwealth of Australia 2017)

Australian Marine Park	Conservation Values	Distance from Development
Kimberley Marine Park	• Marine Park provides protection for the communities and habitats of waters offshore of the Kimberley coastline ranging in depth from less than 15 to 800 m. • Important foraging areas for migratory seabirds, migratory dugongs, dolphins and threatened and migratory marine turtles. • Important migration pathway and nursery areas for the protected humpback whale. • Adjacent to important foraging and pupping areas for sawfish and important nesting sites for green turtles.	~ 40 km from the Browse Development Area The BTL route runs through the Multiple Use Zone (IUCN VI) of the Kimberley Marine Park for a distance of approximately 76 km.
Argo-Rowley Terrace Marine Park	• Marine Park provides protection for the communities and habitats of the deeper offshore waters of the region in depth ranges from 22 to 5000 m. • Marine Park provides protection for many seafloor features including aprons and fans, canyons, continental rise, knolls/abyssal hills and the terrace and continental slope. • Marine Park provides connectivity between the Mermaid Reef Marine Park / WA Rowley Shoals Marine Park and the deeper waters of the region.	~ 125 km from the Browse Development Area. The BTL route runs through the Multiple Use Zone (IUCN VI) of the Argo-Rowley Terrace Marine Park for a distance of approximately 82 km.

Australian Marine Park	Conservation Values	Distance from Development
Mermaid Reef Marine Park	• National and international significance due to its pristine character, coral formations, geomorphic features and diverse marine life. • Key area for over 200 species of hard corals and 12 classes of soft corals with coral formations in pristine condition. • Important areas for sharks, marine turtles, toothed whales, dolphins, tuna and billfish. • Important resting and feeding sites for migratory seabirds. • The reserve provides the best geological example of shelf atolls in Australia.	~ 325 km from the Browse Development Area. ~ 16 km from the BTL route at its closest point.
Ashmore Reef Marine Park	• Nesting and feeding habitat for protected marine reptile species. • Supports dugong population. • Supports some of the most important seabird breeding colonies on the North West Shelf. • Cultural and heritage sites such as Indonesian artefacts and grave sites.	~ 230 km to the north of the Browse Development Area.
Cartier Island Marine Park	• Important area for protected species such as marine reptiles, seabird breeding colonies and migratory seabirds.	~ 230 km to the north of the Browse Development Area.
Roebuck Marine Park	• Foraging area adjacent to important breeding areas for migratory seabirds. • Foraging area adjacent to important nesting sites for flatback turtles. • Includes part of the migratory pathway of the protected humpback whale. • Adjacent to important foraging, nursing and pupping areas for freshwater, green and dwarf sawfish and foraging and calving areas for Australian Snubfin, Indo-Pacific Humpback and Indo-Pacific bottlenose dolphins.	~ 430 km from the Browse Development Area. ~ 230 km south-east of BTL route at its closest point.
Eighty Mile Beach Marine Park	• Foraging areas adjacent to important breeding areas for migratory seabirds. • Foraging areas adjacent to important nesting sites for marine turtles. • Includes part of the migratory pathway of the protected humpback whale. • Adjacent to important foraging, nursing and pupping areas for freshwater, green and dwarf sawfish.	~ 515 km from the Browse Development Area. ~ 150 km south-east of BTL route at its closest point.

Australian Marine Park	Conservation Values	Distance from Development
Dampier Marine Park	• Foraging areas adjacent to important breeding areas for migratory seabirds. • Foraging areas adjacent to important nesting sites for marine turtles. • Includes part of the migratory pathway of the protected humpback whale. • The reserve provides a high level of protection for offshore shelf habitats adjacent to the Dampier Archipelago.	~ 800 km from the Browse Development Area. ~ 105 km south-east of BTL route at its closest point.
Montebello Marine Park	• Foraging areas adjacent to important breeding areas for migratory seabirds. • Foraging areas for vulnerable and migratory whale sharks. • Foraging areas adjacent to important nesting sites for marine turtles. • Includes part of the migratory pathway of the protected humpback whale.	~ 860 km from the Browse Development Area. ~ 62 km south-east of BTL route at its closest point.
Gascoyne Marine Park	• Important foraging areas for migratory seabirds, the threatened and migratory hawksbills and flatback turtles and the vulnerable and migratory whale shark.	~ 1080 km from the Browse Development Area. ~ 280 km south-east of BTL route at its closest point.

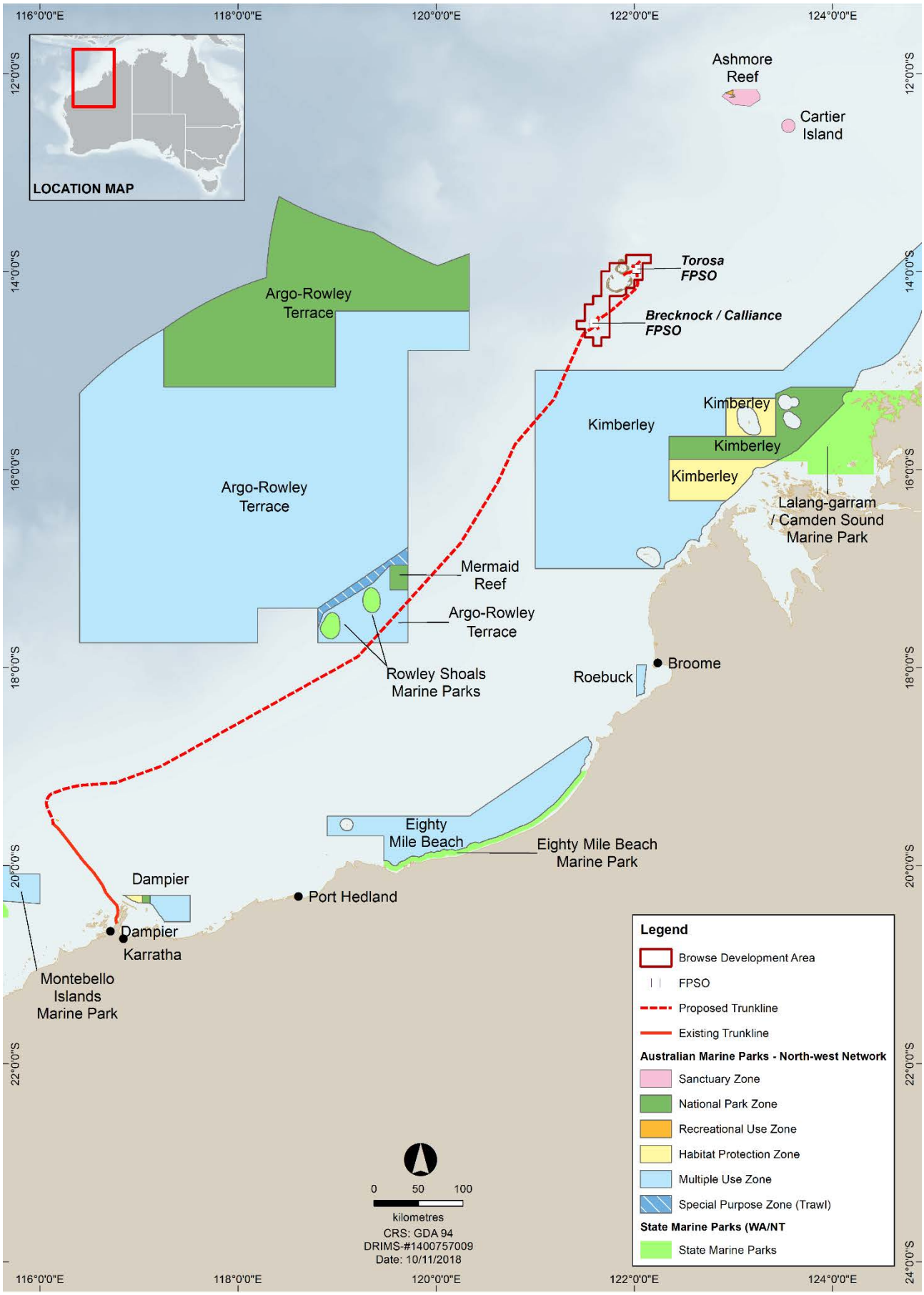

Figure 11 Protected Areas

5.6.5 State Marine Parks and Reserved Land

A number of State Marine Parks and areas of Reserved Land have been established in the broad region of the Project area to protect natural features and aesthetic values. State Marine Parks and Reserved Land in close proximity to the Project area include:

- Rowley Shoals Marine Park located 8 km from the BTL route at its nearest point
- Scott Reef Nature Reserve (including Sandy Islet, East Hook Island and the inter-tidal reef flat). The reserved land is designated for the purpose of 'conservation of flora and fauna' and lies within the Browse Development Area.

Figure 11 shows the State reserves in the vicinity of the Project area.

5.6.6 Ramsar Wetlands of International Importance

The PMST identified no Ramsar Wetlands of International Importance as occurring in close proximity to the Project area.

5.6.7 Nationally Important Wetlands

A wetland may be considered nationally important if it meets at least one of the criteria defined in the Directory of Important Wetlands in Australia.

The PMST identified one Nationally Important Wetland as occurring in close proximity to the Project area being Mermaid Reef (part of Rowley Shoals). The BTL route passes 23 km from Mermaid Reef at its closest point. Mermaid Reef has been described in **Section 5.2** and **5.3**.

5.7 Socio-Economic and Cultural

5.7.1 Heritage Values

5.7.1.1 Indigenous Heritage

No known sites of Aboriginal Heritage significance are located within the Project area according to the WA Department of Planning, Lands and Heritage Aboriginal Sites Inquiry System. The existence of any unknown Aboriginal sites or artefacts of significance within the Project area, or the wider North-west Marine Region, is considered highly unlikely due to the site's remote location offshore.

5.7.1.2 Marine Archaeology

Shipwrecks older than 75 years are protected under the *Commonwealth Historic Shipwrecks Act 1976*, while those dated pre-1900 are protected by WA law under the *Maritime Archaeology Act 1973*. The Australian National Shipwreck database and the WA Maritime Museum Shipwreck Database list the following protected historic wrecks in or in close proximity to the Project area (DOEE 2018g; WAM 2009).

- The shipwreck of the Yarra is located at South Scott Reef. The Yarra was an iron barque vessel with a load of guano that struck the reef during a gale in 1884 (Souter 2009). The wreck of the Yarra is located on the shallow reef flat to the north side of Sandy Islet. The wreck is exposed on the reef flat at low tide.
- A wreck that is believed to be that of the English whaler the 'Lively' which was lost when it struck the western edge of Mermaid Reef (approximately 40 km from the BTL route) sometime between 1801 and 1820. The two anchors and several iron knees from the wreck still lie on the reef flat on the western side and some recovered material is now housed at the WA Museum in Fremantle. The trypots and cannon remain in an underwater gully off the edge of the reef near the anchors (DOEE 2018g).
- The wreck of the Haw Kiet which sunk in 2003 is located approximately 35 km from the BTL route. Little information is available with regards to this shipwreck.

5.7.2 Fisheries

5.7.2.1 Commonwealth and State Managed Fisheries

The diverse range of habitats and species within the North-west Marine Region, has allowed for various fisheries to develop and operate throughout the region. Australian Fisheries Management Authority (AFMA) manages more than twenty fisheries on behalf of the Commonwealth Government and is bound by objectives under the *Fisheries Management Act 1991.* WA State commercial fisheries are managed by the WA Department of Fisheries (WA DOF) under the *Fish Resources Management Act 1994* (FRMA), Fisheries Resources Management Regulations 1995, relevant gazetted notices and licence conditions and applicable Fishery Management Plans.

The State and Commonwealth managed commercial fisheries that occur in the Project area include:

Commonwealth

- North West Slope Trawl Fishery (NWSTF)
- Western Tuna and Billfish Fishery
- Southern Bluefin Tuna Fishery
- Western Skipjack Tuna Fishery.

State

- Northern Demersal Scalefish Managed Fishery (NDSF)
- Mackerel Managed Fishery
- Western Australia North Coast Shark Fishery (WANCSF)
- Onslow Prawn Managed Fishery
- Abalone Fishery
- South west Coast Salmon
- Pilbara Fish Trawl and Trap Fishery
- Specimen Shell
- Marine Aquarium Fish
- West Coast Deep Sea Crustacean
- Pearl Oyster Managed Fishery.

Of the Commonwealth managed commercial fisheries, fishing only occurs in close proximity to the Project area in the NWSTF. The NWSTF extends, from 114 °E to 125 °E, from the 200 m isobath to the outer limit of the Australian Fishing Zone (200 nautical miles from the coastline, which is the boundary of the EEZ. The NWSTF traditionally targets scampi and deep water prawns. Fishing for scampi occurs over soft, muddy sediments or sandy habitats, typically at depths of 200–400 m using demersal trawl gear on the continental slope. Two vessels operated in the fishery in the 2015-16 season, an increase from one vessel in the 2014-15 season (Woodhams and Bath 2017). Efforts were focused in waters beyond the 200 m isobath. The BTL route passes through area of low fishing (Woodhams and Bath 2017). The most recent available data is from the 2015/2016 catch which indicates annual catch are consistent over the last 5 years (~ 33 tonnes per annum).

Of the State managed commercial fisheries the Project area is located within Fishing Area 2, Zone C (offshore zone) of the NDSF with most historical fishing effort being undertaken in Zone B which is located over 150 km from the Project area. This zone is limited to 11 licenses with estimated catch being 1,107 tonnes per season. The Mackerel Managed Fishery also occurs in the Project area with 65 current permits and an estimated catch being 307 tonnes per season.

For the remaining State managed fisheries, fishing in close proximity to the Project area is considered unlikely based on historical fishing records, water depths and fishing methods.

5.7.2.2 **Aquaculture**

There are no aquaculture activities within the area as these are typically restricted to shallow coastal waters.

5.7.2.3 **Traditional Fisheries**

Indonesian fishers have traditionally visited reefs in the North-west Marine Region to collect target species such as trepan (sea cucumber), shark fin and other marine species that are economically significant. In 1974, the memorandum of understanding (MoU) 74 was signed by the Governments of Australia and Indonesia that allowed Indonesian fishers to continue to fish using “methods which have been the tradition over decades of time”. Traditional fishing was allowed within the 12 mile fishing zones that existed around a number of reefs or islets including Scott Reef, which is currently the principal reef to which Indonesian fishers regularly sail on a seasonal basis to harvest trepang and other reef species.

From 2006 to 2008, Woodside commissioned a series of baseline studies, in partnership with the Australian National University, to further understand the traditional practice of Indonesian fishers that journey to Scott Reef. In 2007, an estimated 800 fishers (approximately 80 vessels) travelled from these home islands to Scott Reef mainly to collect trepang.

5.7.3 Other Users

5.7.3.1 **Scientific Research**

Within the Project area, scientific research is predominately undertaken at Scott Reef. A number of marine research and monitoring programs have been undertaken, particularly those conducted by AIMS and the WA Museum. AIMS has been undertaking long-term monitoring of coral and fish communities at Scott Reef since 1993, involving up to six trips a year to the reef.

Other organisations that have been involved in undertaking or funding research activities at Scott Reef include WA DOF, CSIRO and the Australian Research Council (ARC).

The WA DOF also conducts regular monitoring and research programs in the region of the Project area. These activities are designed to collect fishery independent stock assessment data for management of each relevant fishery. Research/monitoring may take place ‘on-board’ existing commercial vessels or independently using dedicated research vessels.

5.7.3.2 **Tourism**

Recreation and tourism activities in the North-west Marine Region occur predominantly in WA State waters, adjacent to population centres (e.g. Broome), with a peak in activity during the winter months (dry season) (Commonwealth of Australia 2017). These activities include recreational fishing, diving, snorkelling, wildlife watching and boating.

Scott Reef has the potential to provide significant opportunities for pelagic sport fishing, however, given the distance from Broome and closest landfall and associated costs, only a limited number of charter operators are prepared to take recreational fishers out to the reef. Those companies that do visit Scott Reef tend to make the trip only four to five times per year, spending around five days at the reef each time.

Similarly, tourism to Rowley Shoals is limited by distance and the availability of safe anchorage. Approximately 300 visitors visit the shoals on an annual basis (DEC 2007).

5.7.3.3 **Shipping**

Shipping activity in and around the Project area for the subsea infrastructure is sparse with the main commercial shipping routes located approximately 50 to 100 km west of Scott Reef. Six shipping fairways cross the BTL route with one of these experiencing a relatively high density of shipping. The main shipping activity in the North-west Marine Region relates to transits to and from Broome (Woodside 2009), transporting goods between Australian and international ports (Commonwealth of Australia 2017). Major ports are adjacent to the Roebuck, Montebello and Dampier Commonwealth marine reserves. Shipping routes from Pilbara Ports to Asia transit to the west of Rowley Shoals (AMSA 2013).

5.7.3.4 **Industry**

The North-west Marine Region supports a number of industries including petroleum exploration and production, as well as minerals extraction.

There are seven sedimentary petroleum basins in the North-west Marine Region: the Northern and Southern Carnarvon basins, Perth, Browse, Roebuck, Offshore Canning and Bonaparte basins. Of these, the Northern Carnarvon, Browse and Bonaparte basins hold large quantities of gas and comprise most of Australia's reserves of natural gas.

The closest approved and prospective petroleum activities to the Project area are the ConocoPhillips Greater Poseidon permits areas (exploration and appraisal drilling) which lie adjacent to the Project area; and the Ichthys (INPEX) and Prelude (Shell) developments, both of which are operating projects located over 120 km north east of the FPSO upstream infrastructure.

The export BTL route crosses two submarine cables south west of Rowley Shoals. One of these cables, the North West Cable System, also runs close to the proposed FPSO upstream infrastructure and may at some point be connected to the facilities.

6. Nature and Extent of Likely Impacts

6.1 Impact Assessment Approach

An environmental risk and impact assessment of the Proposed Action has been undertaken in accordance with Woodside's Environment Impact Assessment Guideline. This guideline and associated Environment Impact Assessment Guidance Tool and Environment Risk Assessment Guidance Tool; support the implementation of impact assessments and set out the broad principles and high level steps for assessing environmental impacts across the lifecycle of Woodside's activities.

Within this process, a distinction is made between an 'impact' and a 'risk' as follows:

Environmental Impact: An expected change to the environment, whether adverse or beneficial, wholly or partially resulting from the Planned and routine project activities including mitigation measures (i.e. routine liquid discharges).

Environmental Risk: A change to the environment resulting from an unplanned event or incident (i.e. oil spill resulting from vessel collision).

The impact assessment approach undertaken included the following steps:

1. Identification of project **aspects** (i.e. results of planned or unplanned project activities that have the potential to impact on the environment).
2. Identification of the **receptors** (i.e. physical, biological, cultural or human elements of the environment that may be impacted by project aspects).
3. Assessment of the **receptor sensitivity** (i.e. the sensitivity/vulnerability/importance of the /receptor) as either high, medium or low value.
4. Assessment of the **magnitude** (i.e. no lasting effect, slight, minor, moderate, major or catastrophic) of the credible environmental impacts from each aspect based on the extent, duration, frequency and scale.
5. Assigning an **impact significance level** to each environmental impact based on the receptor sensitivity and the magnitude of the impact.
6. Assigning an **environment risk consequence** to each environmental risk based on the receptor sensitivity and magnitude of the impact; and the likelihood of occurrence.
7. Utilising the impact significant level to undertaken an assessment of the Proposed Action against the EPBC Act Significant Impacts Criteria and the Western Australian EPA Objectives.

The environmental impact and environmental risk associated with the Proposed Action were assessed via a risk assessment workshop held in November 2017. An internal peer review of the outcomes of the risk assessment was held in early December 2017.

6.2 Environmental Impact Assessment

The following impact significant levels may be assigned for the environmental impacts:

- Catastrophic (A) - Applicable limits or standards are substantially exceeded and/ or catastrophic or major magnitude impacts are expected to receptors of medium/ high or high sensitivity respectively.
- Major (B) - Applicable limits or standards are exceeded and/ or moderate, major or catastrophic magnitude impacts are expected to occur to receptors of high, medium or low sensitivity respectively.

- Moderate (C) - Impacts are close to applicable limits or standards, or within standards but with potential for occasional exceedance. Minor, moderate or major magnitude impacts are predicted to occur to receptors of high, medium or low sensitivity respectively.
- Minor (D) - Impact magnitude is within applicable standards but is considered to have significance. Slight, minor or moderate impacts are predicted to occur to receptors of high, medium or low sensitivity respectively.
- Slight (E) - The receptor will experience a noticeable effect, but the impact magnitude is sufficiently small and well within applicable standards, and/or the receptor is of low value.
- Negligible (F) - The receptor will essentially not be affected.

The outcomes of the preliminary environment impact assessment of planned activities are shown in **Table 13**.

Table 13 Preliminary Environmental Impact Assessment

Ref.	Aspect	Source/Activity	Receptor Sensitivity Level	Predicted Impact	Impact Significance Level
IMP-1	Underwater noise emissions	Noise emissions during drilling and completion of the wells, wellheads, piling, routine FPSO, vessel and aviation operations	High value species (e.g. cetaceans)	Slight impact (behavioural, avoidance) on high value species on a near-field scale for duration of activities.	D – Minor
IMP-2a	Light emissions	Light emissions from drilling MODUs and FPSO	High value species (e.g. marine turtles)	Slight impact (attraction/repulsion, disorientation) on high value species on a near-field scale for duration of the activities.	D – Minor
IMP-2b	Light emissions	Light emissions from vessels	High value species (e.g. seabirds and migratory birds)	Slight impact (attraction/repulsion, disorientation) on high value species on a near-field scale for duration of the activities.	D – Minor
IMP-3a	Physical presence of infrastructure during construction	Seabed disturbance from seabed preparation, MODU anchors and FPSO anchoring and mooring lines	Medium value habitat (not impacting Scott Reef or Rowley Shoals)	Slight impact (due to short duration) to medium value habitat on a localised scale during construction activities.	E – Slight
IMP-3b	Physical presence of infrastructure during operations	1. Permanent subsea infrastructure including the BTL and inter-field spur line 2. FPSO facilities, anchoring and mooring lines, associated petroleum safety zones and condensate tankers	Medium value habitat (not impacting Scott Reef or Rowley Shoals)	Slight impact (due to low magnitude) to medium value habitat on a localised scale for the duration of the activities.	E - Slight

Ref.	Aspect	Source/Activity	Receptor Sensitivity Level	Predicted Impact	Impact Significance Level
IMP-4a	Gaseous Emissions - Air Emissions	Gaseous emissions emitted from diesel generators used on MODU and support vessels to generate power; power generation using diesel and from FPSO facilities	Low value (remote location with limited sensitive receivers)	Slight reduction in air quality on a local scale for the duration of the activities.	F - Negligible
IMP-4b	Gaseous Emissions - GHG	Gaseous emissions emitted from various sources of GHG emissions such as venting, diesel generators used on MODU and support vessels to generate power; power generation using diesel and from FPSO facilities	Low value (remote location with limited sensitive receivers) Consideration of contribution to Australian and Global GHG emissions and subsequent impacts given.	Moderate contribution to Australia's GHG emission.	D - Minor
IMP-5	Treated sewage	Discharge of sewage and sullage (within regulatory discharge limits)	Medium value (open offshore waters)	Slight impact as a result of near-field nutrient enrichment of surrounding waters in offshore open ocean waters.	E - Slight
IMP-6	Treated Process Water (PW) and NORMs.	1. Discharge of PW to the marine environment (within accepted industry standards limits) 2. Discharge of formation water from MODU during well clean-up activities 3. Release of Naturally Occurring Radioactive Materials (NORMs) contained in sand and	Medium value (open offshore waters)	Minor impact as a result of near-field contamination to surrounding waters above relevant guidance/ background levels for the duration of the activity.	D – Minor

Ref.	Aspect	Source/Activity	Receptor Sensitivity Level	Predicted Impact	Impact Significance Level
		scale (if produced) to marine environment			
IMP-7a	Treated utility water – Drain Discharges	Discharge of drain discharges potentially containing oil and grease	Medium value (open offshore waters)	Negligible impact as a result of temporary localised contamination to surrounding waters.	F - Negligible
IMP-7b	Treated utility water – Desalination Brine	Discharge of desalination brine	Medium value (open offshore waters)	Negligible impact as a result of temporary localised contamination to surrounding waters.	F - Negligible
IMP-8	Cooling water	Discharge of cooling water to the marine environment	Medium value (open offshore waters)	Minor, near-field contamination to surrounding waters above relevant guidance/ background levels for the duration of the activity.	D – Minor
IMP-9	Putrescible organic waste	Disposal of food scraps and other putrescible wastes from offshore facilities	Medium value (open offshore waters)	Negligible, localised impact to surrounding waters as a result of nutrient enrichment for the duration of the activity.	F - Negligible
IMP-10	Inorganic non-hazardous waste	Generation and disposal of general inorganic non-hazardous wastes from offshore activities	Low (licensed disposal facility)	Negligible localised impacts to a low value environment (licensed disposal facility) for the duration of the activities.	F - Negligible
IMP-11	Hazardous waste - chemicals, radioactive and medical	Generation and disposal of hazardous wastes from offshore activities	Low (licensed disposal facility)	Slight localised impacts to a low value environment (licensed disposal facility) for the duration of the activities.	F - Negligible

Ref.	Aspect	Source/Activity	Receptor Sensitivity Level	Predicted Impact	Impact Significance Level
IMP-12	Drilling cuttings and fluids	Generation of drill cuttings	Medium value (sparse deep water benthic habitats)	1. Slight, short term decrease in water quality on near field scale. 2. Slight, localised impact on benthic habitat that is permanent.	E - Slight
IMP-13	Subsea control fluid	Discharge of subsea control fluid	Medium value (open offshore waters)	Negligible impact as a result of contamination to surrounding waters that is temporary and localised which may occur sporadically for the duration of the activities.	F – Negligible
IMP-14	Hydrotest Fluid	Discharge of subsea control fluid	Medium value (open offshore waters)	Negligible impact as a result of contamination to surrounding waters that is temporary and localised and will occur only once during commissioning.	F – Negligible

6.3 Environmental Risk Assessment

Environment risk consequences are determined slightly differently than impact significant levels due to the requirement to consider the likelihood that the unplanned event or incident occurs. The likelihood of a risk event occurring can be considered remote (0), highly unlikely (1), unlikely (2), possible (3), likely (4) or highly likely (5). The following risk levels may be assigned for the environmental risks:

- Severe
- Very High
- High
- Moderate
- Low.

The outcomes of the assessment in relation to environmental risks from unplanned incidents or risk events are shown in **Table 14.**

Table 14 Environmental Risk Assessment

Ref.	Aspect	Risk Event	Receptor Sensitivity Level	Risk Consequences	Risk Consequence Level	Likelihood	Risk Rating
Risk-1	Invasive Marine Species (IMS)	Vessel (including FPSO) and MODU movements or ballast water exchange leads to the introduction and establishment of IMS	High value habitat (Scott Reef, Rowley Shoals etc)/native species	Moderate, medium term impact to high value habitat/ native species on a regional scale.	B – Major	1 – Highly unlikely	Moderate
Risk-2	Treated Process Water (PW)	Discharge of PW to the marine environment at levels significantly higher than expected levels	High value habitat (Scott Reef)/native species	Minor, short term impact (contamination) to high value habitat (Scott Reef)/native species.	C - Moderate	0 - Remote	Moderate
Risk-3	Utility Water – Drain Discharges	Unplanned discharge of drain waters potentially containing oil and grease	High value habitat (Scott Reef)/native species	Negligible short term impact (contamination) to high value habitat (Scott Reef)/native species.	E - Slight	1 – Highly unlikely	Low
Risk-4	Cooling water	Cooling water mixing zone significantly larger than predicted resulting in impacts to Scott	High value habitat (Scott Reef)/native species	Slight short term impact (contamination) to high value habitat (Scott Reef)/native species.	D - Minor	0 - Remote	Low

Ref.	Aspect	Risk Event	Receptor Sensitivity Level	Risk Consequences	Risk Consequence Level	Likelihood	Risk Rating
		Reef or high value species					
Risk-5	Non-hazardous inorganic waste	Unplanned discharge of non-hazardous inorganic waste to the marine environment	High value habitat (Scott Reef)/native species	Negligible short term impact (contamination) to high value habitat (Scott Reef)/native species.	E - Slight	1 – Highly unlikely	Low
Risk-6	Hazardous Waste	Unplanned discharge of hazardous waste to the marine environment	High value habitat (Scott Reef)/native species	Slight short term impact (contamination) to high value habitat (Scott Reef)/native species.	D - Minor	2 – Unlikely	Moderate
Risk-7	Drilling cutting and fluids	Distribution and impact of drill cuttings significantly wider than predicted resulting in impacts to Scott Reef	High value habitat (Scott Reef)/native species	Slight short term impact (contamination) to high value habitat/native species.	D - Minor	2 – Unlikely	Moderate
Risk-8	Seabed subsidence	Removal of hydrocarbons from Torosa results in seabed subsidence impacting on the ecological function of Scott Reef	High value habitat (Scott Reef)/native species	Permanent event with negligible impact to high value habitat (Scott Reef)/native species.	E - Slight	1 – Highly unlikely	Low

Ref.	Aspect	Risk Event	Receptor Sensitivity Level	Risk Consequences	Risk Consequence Level	Likelihood	Risk Rating
Risk-9	Hydrocarbon spill	1. Loss of well controls 2. Subsea loss of control 3. Loss of hydrocarbons from topsides 4. Loss of control from substructure (storage of condensate or diesel) 5. Loss of containment from export BTL (gas only) 6. Loss of containment from vessel collision	Multiple high value habitats and high values species	Long term contamination to multiple high value habitats and native species at levels above standards and on a regional scale.	A - Catastrophic	1 – Highly unlikely	High
Risk-10	Underwater Noise	Underwater noise created during pile driving operations in the event pile driving is required in lieu of suction piling	High value habitat (Scott Reef)/native species	Moderate, short term impact (behavioural) to high value species.	C - Moderate	1 – Highly Unlikely	Moderate

7. Measures to Avoid or Reduce Impacts

Section 8 describes the nature and the extent of likely impacts on matters of NES listed under the EPBC Act associated with the Proposed Action. **Section 9** provides an assessment of the nature and the extent of Proposed Action's likely impacts in relation to the WA EPA's Environmental Objectives.

To further reduce likely impacts to matters, a mitigation hierarchy has been applied, to provide best practice in the management of impact through avoidance, management and/or mitigation (reduce, minimise, moderate) defined as:

- Avoidance – measures are taken to avoid an impact from the outset. This is usually undertaken at the early planning stages of a project
- Management – measures that are implemented to control a potential impact when avoidance and mitigation are not possible, and usually involve process and procedures
- Mitigation – proactive measures undertaken to reduce, minimise or moderate potential impacts that cannot be avoided, to As Low As Reasonably Practicable (ALARP) taking into consideration the nature and duration of the impact.

Table 15 presents the preliminary management approach adopted for the Development to avoid, mitigate and/or manage aspects of the Proposed Action. This approach will be refined as the Development progresses with further details to be provided in the relevant approvals documentation. In addition, Environment Plans (EPs) will be prepared for all relevant aspects of the Development for assessment by NOPSEMA under the OPGGS (E) Regulations and the Department of Mines, Industry Regulation and Safety (DMIRS) under the PSL Act. These EPs will detail specific management and mitigation measures as well as environmental performance standards and criteria to be applied to the Development.

Table 15 Management Approach

Aspect	Environmental Objectives	Potential Management Approach
IMP-1, Risk-10: Underwater Noise Emissions	Woodside's environmental objective for the management of underwater noise emissions is to minimise impacts of noise on threatened and migratory species listed under the EPBC Act.	• Suction piling will be selected as the preferred anchoring method where practicable. • Support vessels and helicopters will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale and Dolphin Watching. • Interactions between support vessels and whale sharks will be consistent with the Whale Shark Code of Conduct (DPAW 2013). • Interactions of helicopters with listed species will be in accordance with Part 8 of the EPBC regulations 2000. • Scheduled helicopter flight paths will avoid seabird roosting areas such as Sandy Islet. • If Vertical Seismic Profiling (VSP) is conducted at a drill centre, it will be subject to pre-start marine fauna observations to ensure sensitive fauna are not in the vicinity, aligned with EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales • In the event that impact piling is required for installation of moorings, noise management procedures will be developed and implemented. These will be detailed in the relevant EPs for submission and acceptance by the relevant regulatory authority. • To minimise impacts associated with the construction and operation of the Proposed Action a Cetacean Management Plan will be prepared.
IMP-2: Light Emissions	Woodside's environmental objective for the management of light emissions is to avoid long-term impacts of light emissions on threatened and migratory turtle species listed under the EPBC Act.	• Navigation beacons and lighting will be designed in line with the safety requirements of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and the Navigation Act 2012. • The FPSO will be designed such that continuous flaring will be limited to purge gas, pilot light and waste gas.
IMP-3: Physical presence of infrastructure	Woodside's environmental objectives for the management of the physical presence of infrastructure are to: • Minimise interactions between EPBC Act listed species and development infrastructure • Minimise interactions between development infrastructure and other vessels (shipping and fishing) • Avoid permanent disturbance to benthic habitats, beyond the physical footprint of the development infrastructure • Avoid permanent disturbance to marine archaeology beyond the physical footprint of the development infrastructure.	• A 500m petroleum safety zone around the FPSO facilities, MODUs and installation vessels will be gazetted underS280 of the OPGGS Act. • The FPSO facilities and associated infrastructure locations are away from sensitive receptors such as Scott Reef and Sandy Islet. Benthic habitat surveys have been undertaken or are planned in relation to the BTL and the inter-field spur line. • FPSO facilities will be located away from shipping lanes and approach and exit paths to Scott Reef that traditional Indonesian fishers would likely take. • For subsea infrastructure, in particular flowlines, seabed preparation, trenching and secondary stabilisation requirements will be limited to the level necessary to ensure pipeline integrity. • No permanent moorings will be installed within the lagoon at North and South Scott Reef. • Ongoing consultation with commercial fishers, recreational fishing groups and other relevant stakeholders that operate in the Project area will be undertaken. • Shipwrecks identified during surveys or installation activities will be avoided and reported in accordance with the *Historic Shipwrecks Act 1976*.
IMP-4: Gaseous Emissions - Air emissions and GHG	Woodside's environmental objective for the management of gaseous emissions is to optimise efficiencies in air emissions and reduce carbon emissions to ALARP.	• The Development will comply with Australian greenhouse gas requirements; the National Greenhouse Energy Reporting Act and the Safeguard Mechanism. • Avoiding the need to incinerate the acid gas vent stream by routing to a high point on the flare stack for safe dispersion. • Fuel usage will be recorded for FPSO facilities, MODU and vessels associated with the Development and emissions will be derived from fuel usage. • Vessels will comply with MARPOL 73/78 Annex VI (Prevention of Air Pollution from Ships) requirements as defined in the Marine Order 97 (Marine Pollution Prevention, Air Pollution) (pursuant to the *Commonwealth Navigation Act 1912*). • Low sulphur diesel will be used when it is available.
IMP-5: Treated sewage	Woodside's environmental objective for the management of sewage discharges is to prevent impacts to Scott Reef from the discharge of untreated sewage.	• Vessels and FPSO will conform with MARPOL 73/78Annex IV: Sewage – (as applied in Australia under Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*); AMSA Marine Orders - Part 96: Marine Pollution Prevention – Sewage. • No discharge of untreated sewage will occur within three nautical miles from Scott Reef.
IMP-6, Risk-2: Treated Process Water (PW)	Woodside's environmental objective for the management of PW discharge is to avoid significant changes to water quality resulting in impacts to Scott Reef from the discharge of PW.	• Where practicable, design of the development infrastructure will take into consideration opportunities to reduce the need for chemical additives (e.g. the use of active heating for hydrate management). • Chemicals used will be selected to have the lowest environmental toxicity rating possible whilst meeting operational performance requirements in accordance with Woodside's Chemical Selection and Approval Procedure. • PW will be treated to meet defined specifications that meet Woodside and accepted industry standards (ALARP) prior to being discharged overboard. Proposed PW discharge specifications area presented in **Table 7**. • The discharge of PW at the FPSO facilities will be conducted in deep water away from sensitive receptors such as Scott Reef.

Aspect	Environmental Objectives	Potential Management Approach
		• PW discharge will be conducted below the water surface to maximise dispersion. • Baseline, periodic and 'for cause' toxicity testing of the PW stream will be undertaken against the recognised ecotoxicity assessment methodology defined in ANZECC/ARMCANZ (2000). • In the event the PW discharge does not meet the no effect thresholds in the range predicted for any contaminant concentrations, an adaptive management strategy will be developed and implemented. • PW modelling and infield verification post RFSU will be completed to define mixing zone and demonstrate better than 99% species protection within 3Nm of Scott Reef.
IMP-7a, Risk-3: Treated utility water – Drain Discharges	Woodside's environmental objective for the management of drain discharges is to avoid significant changes to water quality resulting in impacts to Scott Reef from the discharge of drain discharges.	• The MODU and FPSO facilities will be designed to allow segregation of drainage into open and closed drain systems. • Areas of potential contamination such as machinery and bulk liquid storage areas will be bunded to capture any spilled chemicals or oil residues. Drainage from these areas will be directed to holding tanks for treatment prior to discharge. • An oil-in-water separator will be available onboard the FPSO facilities, MODU and vessels, which will be maintained and operated so that the slops/bilge stream is treated to reduce hydrocarbon concentrations below 15 ppm in accordance with MARPOL 73/78 Annex I, as applied in Australia under the Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Part II Prevention of pollution from oil); Marine Orders 91 (Marine pollution prevention – Oil) 2006 as applicable to vessel class; and the *Pollution of Waters by Oil and Noxious Substances* Act 1987 (WA). • Discharges from slop tanks will be monitored to ensure specifications are met. Where discharge specification cannot be met for FPSO facility discharges, the discharge stream will be reprocessed or sent onshore for disposal.
IMP-7b: Treated utility water – Desalination Brine	Woodside's environmental objective for the management of desalination brine discharges is to prevent impacts to Scott Reef from the discharge of desalination brine.	• The discharge of desalination brine at the FPSO facilities will be conducted in deep water, away from sensitive receptors such as Scott Reef. • Biocides and anti-scaling agents will be selected in line Woodside's Chemical Selection and Approval Procedure based on their low inherent toxicity, suitable for use in potable water systems.
IMP-8, Risk-4: Cooling Water	Woodside's environmental objective for the management of cooling water discharge is to record no detectable change from natural variation beyond the predicted mixing zone as a result of cooling water discharge.	• Cooling water systems have been designed to be segregated from process hydrocarbon streams. • Cooling water discharge will be conducted below the water surface, to increase dispersion. • The discharge of cooling water at the FPSO facilities will be conducted in deep water, away from sensitive receptors such as Scott Reef. • Hypochlorite will be used to control fouling in sea water systems in line with best practice, due to its high water solubility and biodegradability. • During FPSO operations, chlorine concentrations of the cooling water stream will be routinely maintained not to exceed 0.2 parts per million (ppm) at the point of discharge. Higher concentrations of up to 0.5 ppm may occur at times, if shock dosing is required. • Cooling water modelling and infield verification post RFSU will be completed to define mixing zone and demonstrate better than 99% species protection within 3nm of Scott Reef for toxicity and temperature.
IMP-9/10: Putrescible organic waste/ Inorganic non-hazardous waste (Risk-5)	Woodside's environmental objectives for the management of non-hazardous solid waste are to: • Avoid impacts to the marine environment from the generation of non-hazardous solid wastes (including putrescible waste) during all phases of the development • Avoid unplanned release of non-hazardous solid waste (including putrescible waste) to the marine environment.	• Waste storage areas on the FPSO facilities and vessels allow segregation into recyclable and non-recyclable wastes. • Segregated waste on FPSO facilities and vessels will be securely stored through the provision of appropriate waste receptacles and suitable containment measures such as lids and netting to prevent any loss of wastes to the marine environment. • Generated inorganic non-hazardous solid waste will be transported onshore to a recycling contractor or appropriate waste disposal site in accordance with MARPOL 73/78 Annex V: Garbage (as implemented in Commonwealth waters by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*) and Marine Orders - Part 95: Marine Pollution Prevention – Garbage. • No routine discharge of inorganic non-hazardous solid waste will take place at sea in accordance with Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act* 1983 - Parts IIIA and IIIC.
IMP-11, Risk-6: Hazardous waste - chemicals, radioactive and medical	Woodside's environmental objectives for the management of hazardous waste are: • No routine release of hazardous waste to the marine environment • No impact to Scott Reef from the accidental release of hazardous wastes at sea.	• Hazardous waste will be segregated in hazardous waste skips and drums or holding tanks (for liquid wastes) prior to disposal. • Hazardous waste will be transported to shore for disposal in accordance with MARPOL 73/78 Annex III: Packaged Harmful Substances (as implemented in Commonwealth waters by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*) and Marine Orders - Part 94: Marine Pollution Prevention – Packaged Harmful Substances. • Waste management measures will be included in the relevant EPs, and will specify the appropriate disposal method for hazardous waste, including NORM and mercury-contaminated solids (if encountered). • Hazardous waste will not be discharged at sea in accordance with Commonwealth *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* - Parts IIIA and IIIC and Marine Order 94 (pollution prevention – Packaged Harmful Substances). • Where applicable, hazardous waste will be handled and stored in accordance with the relevant SDS and tracked from source to its final destination.
IMP-12, Risk-7: Drilling cuttings and fluids	Woodside's environmental objectives for the management of drill cuttings and fluids are to: • Minimise volumes of drilling fluids and cuttings discharged to the marine environment.	• Well count will be optimised to meet recovery objectives and operational requirements and thereby reduce unnecessary use of drill fluids and generation of drill cuttings. • Where required NWBFs will be selected in accordance with Woodside's chemical selection procedure. • Risers will be used to ensure that NWBF and associated cuttings are recirculated to the MODU for treatment prior to discharge.

Aspect	Environmental Objectives	Potential Management Approach
	• Avoid impacts to Scott Reef from the discharge of drill cuttings and fluids.	• There will be no discharge of whole NWBF at sea during drilling and completion operations. • Drill cuttings will be tested to confirm that the average oil on cuttings for the entire well (sections using NWBM) will not exceed 6.9% by wet weight prior to discharge. • Given the potential sensitivities of Scott Reef coral communities to sedimentation, an adaptive management strategy for the disposal of drill cuttings from Torosa wells will be adopted. For those drill centres where surface discharge of drill cuttings results in impacts to the reef, alternative drill cuttings disposal techniques will be used, which may include: - Discharge from the MODU at a sufficient depth to allow acceptable dispersion to occur - Retain cuttings, store and ship to an offshore location away from the reef for offshore disposal - Retain cuttings, store and transfer to shore for disposal.
IMP-13: Subsea control fluid	Woodside's environmental objective for the management of subsea control fluids is to avoid the risk of significant changes in water quality resulting in long-term impacts to Scott Reef associated with discharges of subsea control fluids, without compromising the integrity of the subsea infrastructure.	• The selected subsea control fluid will have an OCNS rating of Group D or better. • Subsea fluid usage will be monitored through the life of the development.
IMP-14: Hydrotest Fluid	Woodside's environmental objective for the management of hydrotest fluid discharge is to avoid significant changes to water quality resulting in impacts to Scott Reef from the discharge of hydrotest fluids.	• Subsea infrastructure installation schedule will be optimised to minimise the requirement for discharge and refill of hydrotest fluid. • Hydrotest fluid will be selected for environmental performance (i.e. low toxicity chemicals) while maintaining technical performance requirements. • Hydrotest fluid discharge will be detailed in the relevant EPs developed during the detailed engineering and design studies for the development. The plan will detail hydrotesting requirements, including details on the specific chemical additives to be selected as well as likely concentrations, volumes and frequency of discharges. • The discharge of hydrotest fluid will be conducted in a controlled manner to ensure adequate dilution. • Where manifolds are located in State Waters, the hydrotest fluid shall be discharged from the location furthest away from Scott Reef.
Risk-1: Invasive Marine Species IMS	Woodside's environmental objective for the management of IMS is to avoid the introduction and successful establishment of IMS at Scott Reef.	• Woodside's IMS Management Plan will be implemented (including risk based assessment and implementation of management options as required by the plan) to reduce the risk of introducing IMS to Australian waters. This may include inspections prior to entry into Australian waters and the use of antifouling coating. • All vessels and MODU will be required to meet both Commonwealth and State ballast water and biofouling legislation and guidelines including the Ballast Water Management Requirements and the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry. • The location of FPSO facilities will be in deep water and distant from Scott Reef, inherently reduces the risk of transfer and successful settlement of IMS at Scott Reef.
Risk-8: Seabed subsidence	Woodside's environmental objectives for the management of seabed subsidence are to: • Avoid long-term negative effects to coral health at Scott Reef from sea level change attributable to seabed subsidence resulting from production at Torosa • Avoid long-term negative effects to turtle nesting at Sandy Islet from sea level change attributable to seabed subsidence resulting from production at Torosa.	Given the level of confidence with the low magnitude of subsidence predicted from the Development, no management measures are proposed to reduce the risk of environmental impact associated with subsidence.
Risk-9: Hydrocarbon spill	Woodside's environmental objective for the management of accidental hydrocarbon releases is to prevent accidental releases.	<u>Drilling and completion activities</u> • During drilling, proven systems and procedures will be employed. These will be applied and supervised by highly competent and experienced personnel to minimise the potential for loss of well control, leading to well blow-out. • Drilling and completion activities will only be undertaken when metocean conditions are deemed suitable for safe operations. • Reservoirs will be isolated from the surface by a minimum of two independent and verifiable barriers. The configuration of isolation barriers during the drilling phase typically includes: - Overbalanced hydrostatic pressure maintained on the reservoir via the drilling fluids. Drilling fluids are contained by the cemented casing to the mud line and riser to the rig - Seabed BOPs which can be activated to "shut in" the well in the event that well control via overbalanced drilling fluids is lost. • A 500 m petroleum safety zone will be implemented at the drill rig.

Aspect	Environmental Objectives	Potential Management Approach
		• Relief well planning will be outlined in the Oil Pollution Emergency Plan. <u>Commissioning, Operational and IMR Activities</u> • Hydrotesting will be undertaken prior to commissioning to confirm integrity of SURF system • IMR activities to manage integrity of subsea systems will occur throughout operations. • The configuration of reservoir isolation barriers during the operations phase typically includes: - Production tubing from the reservoir to valving on the subsea tree - Cemented casing and associated valving on the subsea tree, plus a production packer to isolate the annulus between the casing and production tubing from the reservoir - A Surface Controlled Subsurface Safety Valve (SCSSSV) will be fitted on all production wells. • The wells, subsea system and FPSO facilities will utilise corrosion resistant materials and be designed to protect against integrity threats (e.g. corrosion, impact, erosion, low temperature embrittlement). • Wellhead valve design and configuration allowing safe operation and control of the well. • FPSO facilities will be designed to include compartmentalised condensate storage. • FPSO facilities are designed with drain systems to prevent spills overboard. • FPSO facilities are assessed against one in 10,000 year return period weather conditions. • FPSO facilities will include double side hull design to minimise risk of hydrocarbon release in the event of a collision • 500 m petroleum safety zones will be maintained at the FPSO facilities. • Design codes and material specifications for all risers and flowlines will be compliant with the relevant Australian and international standards. • Pipelines monitoring will be undertaken including: - Monitoring of corrosion protection system - Periodic inspections using side scan sonar and ROV. <u>Offloading and Refuelling Activities During Drilling and Operations</u> • Condensate offtake hoses will be fitted with ‘dry break’ or ‘breakaway’ couplings. • Scuppers and save-alls, including those around tank vents, will be in place before commencement of refuelling activities. • Diesel refuelling hose inventory will be drained before disconnection. • Diesel refuelling station will be isolated and equipment stowed when not in use. • Offloading and refuelling hoses will be certified as suitable for a safe operating pressure range. The hoses and fittings will also be compatible with support vessel/condensate tanker pump pressures. • Support vessel/condensate tanker pumps will be fitted with relief valves to allow diverting back of fluids to source in the event of excessive pressure build up in the transfer hose. • Where practicable, refuelling of support vessels will be conducted in port. • Tank levels will be continuously monitored to prevent overflow, and tank level indication and level alarms are provided for diesel storage tanks. • All vessels will be required to have in place a Ship-Board Oil Pollution Emergency Plan (SOPEP)/ Ship-board Marine Pollution Emergency Plan (SMPEP) including oil spill response measures. • Offloading and refuelling will only be undertaken when metocean conditions are deemed suitable for safe operations. • Offtake vessels will be piloted during berthing and offloading operations. • Offloading and refuelling will be undertaken by trained personnel using defined procedures. • Responsibilities and accountabilities will be defined for response and notifications to Woodside and relevant authorities. • A loading plan (volume to be transferred) will be agreed between the supply point (vessel) and the delivery point, and a pre-load checklist completed. • Transfer equipment and emergency shutdown functions will be checked immediately prior to commencement of offtake. • The diesel transfer pumps emergency shutdown system onboard the offloading vessel will be tested at the commencement of transfer. • Communication (visual and/or radio) between the support vessel/condensate tanker will be maintained throughout refuelling and offloading operations. <u>Spill Response</u> In the event of a spill, Woodside will respond in accordance with the EPs and OPEPs specifically developed for the Development, which will be consistent with the National Plan to Combat Pollution of the Sea by Oil and other Noxious and Hazardous Substances and the types of response measures considered in this document. The EPs and OPEPs will detail the spill response and mitigation measures adopted by Woodside following the rigorous risk assessment of a range of spill response strategies available to Woodside. These strategies include both strategies to limit the volume of hydrocarbons being released to the marine environment and strategies to reduce the volume of hydrocarbons reaching sensitive receptors.

8. Summary of Assessment against EPBC Act Significant Impacts Criteria

An assessment of the Proposed Action against the EPBC Act Significant Impacts Criterial is provided in **Table 16**.

Table 16 Summary of Assessment against EPBC Act Significant Impacts Criteria

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment	Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
Listed Threatened Species and Ecological Communities	An action is likely to have a significant impact on a species listed in any of the following categories if there is a real chance or possibility that it will: **Extinct in the wild** • Adversely affect a captive or propagates population or one recently introduced / reintroduced to the wild, or • Interfere with the recovery of the species or its reintroduction into the wild. **Critically Endangered and Endangered** • lead to a long-term decrease in the size of a population, • reduce the area of occupancy of the species, • fragment an existing population into two or more populations, • adversely affect habitat critical to the survival of a species, • disrupt the breeding cycle of a population, • modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, • result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically	Refer to **Section 5.4.1** for details on protected species. **Extinct in the wild** No extinct in the wild species are expected to occur in the vicinity of the Project area. **Critically Endangered and Endangered Species** Significant numbers of EPBC listed Critically Endangered species are not likely to occur in the vicinity of the Project area and/or interact with the Proposed Action. The following EPBC listed Endangered species have been identified as likely to occur in significant number in the vicinity of the Project area and/or interact with the Proposed Action: • Pygmy Blue Whale (**Section 5.4.4**). Scott Reef and the surrounding waters have been identified as a possible foraging area (DoE Conservation Management Plan for the Blue Whale) for pygmy blue whales. Refer to **Section 5.4.2** for details on BIAs in the vicinity of the Project area. **Vulnerable Species** The following EPBC listed Vulnerable species have been identified as likely to occur in significant numbers in the vicinity of the Project area and/or interact with the Proposed Action: • Australian Lesser Noddy (**Section 5.4.3**)	**Planned and Routine Activities** The aspects resulting from planned and routine activities and an assessment of the predicted environmental impact is provided in **Section 6.2** The aspects that may credibly impact listed threated species are: • IMP-1: Underwater Noise Emissions • IMP-2: Light Emissions • IMP-3: Physical Presence of Infrastructure • IMP-6: Treated Process Water (PW) • IMP-8: Cooling Water. **Unplanned Events and Incidents** The aspects resulting from unplanned events and incident and an assessment of their risk consequence is provided in **Section 6.3**. The following Risk Events would be expected to have the potential to result in negligible or slight impacts on Scott Reef or listed Threatened Species on a near-field basis. As such they are considered to have a risk consequence level of slight to minor. Due to the level of potential impact and the likelihood of the Risk Event occurring (either remote, highly unlikely or unlikely) these risk events are not considered significant. • Risk-3: Utility Water - Unplanned discharge of drain waters containing oil and grease • Risk-4: Cooling Water - Release of cooling water at levels significant above expected • Risk-5: Non-Hazardous Inorganic Waste - Unplanned discharge of non-hazardous organic wastes • Risk-6: Hazardous Waste - Unplanned discharge of hazardous wastes • Risk-7: Drilling Cuttings and Fluids - Distribution and impact of drill cuttings significantly wider than predicted • Risk-8: Seabed Subsidence - Hydrocarbon removal resulting in seabed subsidence. Risk Events that are considered to have a risk consequence level of moderate, major or catastrophic due to their potential magnitude or the potential for impacts on a regional scale are: • Risk-1: Invasive Marine Species - Introduction and establishment of Invasive Marine Species • Risk-2: Treated Process Water - Release of treated process water at levels significant above expected levels • Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill • Risk-10: Underwater noise – Pile driving in the event preferred method of suction piling is not feasible.		**Environmental Impact from Planned and Routine Activities** Based on the predicted impacts of the planned and routine activities and the relevant significance criteria, it is considered highly unlikely that the Proposed Action will have a significant impact on Listed Threatened Species as a result of planned and routine activities. No Impact is expected to occur to Listed Ecological Communities as a result of planned and routine activities. **Environmental Risk from Unplanned Event or Incidents** Based on the predicted impacts that could potentially occur as a result of unplanned events or incidents, the likelihood of these events and resultant impacts occurring and the relevant significance criteria, it is considered highly unlikely that the Proposed Action will have a significant impact on Listed Threatened Species or Threatened Ecological Communities as a result of unplanned events or incidents.
			IMP-1: Underwater Noise Emissions	Underwater water noise emissions resulting from drilling of the wells, wellhead operations; and routine FPSO, vessel and aviation operations may potentially have a slight behavioural impact on listed threatened cetaceans, marine turtles and sharks. These impacts would be expected to occur on a near field scale. *Cetaceans* The Browse Development Area is identified as a possible foraging area (DoE Conservation Management Plan for the Blue Whale) for endangered pygmy blue whales. The National Conservation Values Atlas identifies Scott Reef as a foraging area. Evidence suggests that Scott Reef may be utilised for opportunistic foraging by pygmy blue whales during their migration pathway (**Section 5.4.4**).	Refer to **Table 15** for preliminary management measures relating to underwater noise emissions.	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
	endangered species' habitat, • introduce disease that may cause the species to decline, or • Interfere with the recovery of the species. **Vulnerable** • lead to a long-term decrease in the size of an important population of a species, • reduce the area of occupancy of an important population, fragment an existing important population into two or more populations, adversely affect habitat critical to the survival of a species, • disrupt the breeding cycle of an important population, • modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, • result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat, • introduce disease that may cause the species to decline, or • interfere substantially with the recovery of the species. **Threatened Ecological Communities** An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will: • reduce the extent of an ecological community, • fragment or increase fragmentation of an	• Humpback Whale (**Section 5.4.4**) • Green Turtle (refer to **Section 5.4.6**) • Hawksbill Turtle (refer to **Section 5.4.6**) • Whale Shark (refer to **Section 5.4.5**). A BIA for foraging for Whale Sharks is located in approximately 40 km from the BTL route. Scott Reef and a portion of the surrounding waters are identified as a BIA as inter-nesting areas for green and hawksbill turtles. Sandy Islet on Scott Reef and a 20 km surrounding area has identified as habitat for nesting and inter-nesting critical to the survival of green turtles in the DoEE's Recovery Plan for Marine Turtles 2017-2027. **Threatened Ecological Communities** No Listed Threatened Ecological Communities in close vicinity of the Proposed Action.		The vulnerable humpback whale may occasionally transit the Project area in low numbers. Given that the Project area is not known to provide significant breeding or feeding habitats, only minor impacts are expected to occur, with no long-term effect at population level, as a result of underwater noise emissions from the Development. *Marine Turtles* Disruption to turtles from development noise is expected to be minor due to the transient nature of noise from drilling and completion, installation and commissioning activities, and the low levels of noise during the operations phase in proximity to Sandy Islet. The closest well and associated drilling, completion and installation activities in proximity to turtle nesting habitat at Sandy Islet is expected to be approximately 7 km to the east. Due to the depth of water the wells will be located in, no significant impact from the noise from the wellheads is expected. Noise generated during the drilling operations, particularly from the MODU and vessels on DP may result in behavioural impacts (avoidance behaviour) to inter-nesting turtles within the 20 km interesting zone in the green turtle BIA / critical habitat zone and the hawksbill turtle BIA. Given the small number of wells within this zone, this impact will be temporary in nature and is not expected to be significant. It should also be noted that a moored MODU is planned for the drilling of wells post RFSU. Noise emissions from the MODU on DP are not expected to significant impact turtles close to Sandy Islet due to the significant distance from the closest well (7 km). VSP during drilling will also be a source of underwater noise emission. VSP typically uses up to 3 airguns of 250 cubic inches (cu.in) each (total of 750 cu.in)., discharged approximately five times at 20 second intervals, resulting in sound levels of approximately 238 dB re 1 µPa at 1 m (zero to peak pressure level) (Matthews 2012), with frequencies less than 200 Hz. Sound levels are expected to attenuate rapidly to approximately 180 dB re 1 µPa (zero to peak) within 100 m (Matthews 2012). The process is repeated as required for different stations in the well and may take up to 10 hours to complete. Slight behavioural impacts to inter-nesting turtles may occur, however as these emissions will only occur infrequently and for short durations, this impact is not expected to be significant. *Fish, Sharks & Rays* The majority of activities are expected to generate 'continuous' rather than 'impulsive' noise, and will therefore result in low levels of underwater noise akin to vessel noise. This type of noise is not expected to cause considerable disturbance to fish behaviour including spawning. Higher source levels are expected from VSP, however, any disturbance to fish will be limited to a very short duration as this type of activity will only occur for up to 10 hours per well. Given that relatively low numbers of whale sharks are expected to occur in the vicinity of development activities, and the Project area is not known to provide significant breeding or feeding habitats, only minor impacts are expected to occur, with no long-term effect at population level, as a result of underwater noise emissions from the development. *Assessment* Based on the above potential impacts it is expected that underwater noise emissions will result in a slight impact (behavioural, avoidance) on high value species on a near-field scale for duration of activities. The significance of this impact on listed threatened species is expected to be Minor.		

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
	ecological community, for example by clearing vegetation for roads or transmission lines, • adversely affect habitat critical to the survival of an ecological community, • modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns, • cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting, • cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: - assisting invasive species, that are harmful to the listed ecological community, to become established, - causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or - interfere with the recovery of an ecological community.		IMP-2: Light Emissions	Light emissions from MODUs, FPSO and vessels may potentially have a slight impact (attraction/repulsion, disorientation) on marine turtles and seabirds/shorebirds. Green turtles in the vicinity of Scott Reef, in particular nesting female green turtles at Sandy Islet, have been identified as the main ecological receptor to light emissions associated with the Development. *Marine Turtles* Light studies undertaken in support of the previous Browse FLNG development concept indicate that direct light levels from operations lighting reaching Sandy Islet from the closest MODU and FPSO are likely to be less than 0.01 Lux, with light appearing as a small lit object. Therefore, no disturbance to the nesting behaviour of adult marine turtles is expected from light visible at Sandy Islet. Similarly, hatchlings are unlikely to be disorientated by or attracted to such a light source. It should also be noted that Sandy Islet is a small, low-lying sandy cay with nearby access to the water from all directions. Inter-nesting turtles or turtles passing through the Project area may temporarily alter their normal behaviour whilst attracted to the light spill from infrastructure (Light spill of at least 0.01 Lux (i.e. at least quarter moon levels) is likely to extend 1.2 km radially from the MODU and 15 km radially from FPSO facilities. Given their low density presence within the Project area, the zone of influence and subsequent attraction from direct lighting is expected to be minor and a temporary disruption to a small portion of the adult turtle population and are not considered significant. Flaring from the MODUs and FPSO create temporary light sources at levels above normal operating levels. Based on line of sight assessments undertaken for the previous FLNG concept, flaring from the Calliance/Brecknock FPSO may be visible at portions of Scott Reef (depending on the location of the FPSO). Flaring from the Torosa FPSO and the MODU drilling Torosa wells would be visible at all locations on Scott Reef. However, flaring from the FPSO will not be continuous and will likely only occur for short durations during commissioning, start up and shut down. As such these emissions are not expected to result in significant impacts to turtles at Scott Reef. *Seabirds/Shorebirds* Light from the MODU and FPSO facilities is unlikely to attract a significant number of seabirds or shorebirds as activities are located a considerable distance from known key aggregation areas. As per the above discussion, birds roosting at night on Sandy Islet are unlikely to be disturbed given the low level of artificial light from operational lighting (less than 0.01 Lux) that would be received at Sandy Islet. The short term and infrequent nature of flaring is unlikely to impact nesting or resting seabirds/shorebird on Scott Reef. *Assessment* Based on the above potential impacts it is expected that artificial light emissions will result in a slight impact (attraction/repulsion, disorientation) on high value species on a near-field scale for duration of the activities. The significance of this impact on listed threatened species is expected to be Minor.	Refer to **Table 15** for preliminary management measures relating to artificial light emissions.	
			IMP-3: Physical Presence of Infrastructure	The majority of the infrastructure will be located on the seabed and as such, its presence is not expected to impact listed threated species. Impacts may occur as a result of interaction between construction vessel and individuals, however, these are not expected to occur often and will mainly result in avoidance behaviour.	Refer to **Table 15** for preliminary management	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
				The significance of Impacts from the physical presence of infrastructure on listed threatened species are expected to be Slight.	measures relating to the physical presence of infrastructure.	
			IMP-6: Treated Process Water (PW)	PW will be discharged to the marine environment (within accepted industry limits). This may include the release of NORM associated with sand and scale (if produced). Formation water may also be discharged from the MODU in low quantities during well clean-up activities. This discharge is expected to result in minor impact as a result of near-field discharge to surrounding waters within the Commonwealth Marine Area for the duration of the discharge activity. Modelling undertaken in support of the Browse FLNG EIS predicted that the PW plume would disperse to below toxicity threshold concentrations within less than 3 km from the facility. PW emissions from the FPSO facilities are expected to be broadly similar (other than MEG concentrations are likely to be pulsed at high concentrations as opposed to continuous trace concentrations). There is potential for PW volumes and discharge rates to increase during later field life to levels above predicted in the Browse FLNG EIS. Further studies with respect to PW discharge from the FPSO facilities will be undertaken during future phases. As PW will be treated to meet defined specifications that meet Woodside and accepted industry standards (ALARP) prior to being discharged overboard; and wave and currents are expected to quickly dilute the discharged PW, it is considered highly unlikely that any listed threatened species would be exposed to discharge at concentrations or durations to elicit a toxic response.	Refer to **Table 15** for preliminary management measures relating to the discharge of Treated Process Water.	
			IMP-8: Cooling Water	Cooling water will be discharge to the marine environment from the FPSO, MODU and support vessels. This discharged cooling water will be of a higher temperature than ambient conditions and may contain contaminants (e.g. chlorine). Modelling undertaken in support of the Browse FLNG EIS predicted that temperatures would return to with 3 degrees of ambient temperature within 190 m of the discharge point in winter and 110 m or less in summer. Modelling also predicted that residual chlorine concentrations in cooling water (0.2ppm) will reduce down-current of the discharge point to threshold concentration (0.002ppm) within 1.4 km or less in winter and within shorter distances in the transitional and summer seasons (1.3 km or less and 1.1 km or less respectively) for 95% of the time. Cooling water emissions from each of the FPSO facilities are expected to be significantly reduced compared to those assessed for Browse FLNG EIS. Further studies with respect to cooling water discharge from the FPSO facilities will be undertaken during future phases. Based on the modelling results, the potential for toxicity and thermal effects are expected to be temporary, localised and confined to a small portion of the water column (i.e. surface layer) and exposure of transient marine organisms is expected to be short-lived.	Refer to **Table 15** for preliminary management measures relating to discharge of cooling water.	
			Risk-1: Invasive Marine Species - Introduction and establishment of Invasive	The introduction and establishment of IMS could potentially result in moderate, medium term impacts to habitat and species including listed threatened species on a regional scale. However, given the regulatory requirements and planned prevention measures, including the development of an IMS management plan, the likelihood of IMS being introduced and becoming established is considered highly unlikely.	Refer to **Table 15** for preliminary management measures relating to the prevention of the	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
			Marine Species (IMS)		introduction of invasive marine species.	
			Risk-2: Treated Process Water (PW) - Release of treated process water at levels significant above expected levels	Woodside has significant operating experience in relation to the assessment, management and monitoring of PW discharges. This experience, together with the regulatory requirements, ongoing monitoring, planned management measures and distance to Scott Reef means that the chance of a released of PW at levels and for durations that could conceivable result in significant impacts to threatened fauna is considered remote.	Refer to **Table 15** for preliminary management measures relating to the discharge of Treated Process Water.	
			Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill	A significant hydrocarbon release could potentially result in long term contamination of high value habitat on a regional scale with subsequent impacts to marine fauna including listed threatened species. Such an event could also potentially result in lethal and sub-lethal effects on threatened cetaceans, marine turtles, fish and seabirds. Given the significant engineering and risk mitigation measures to be put in place; and the distance from distant from heavy third-party marine traffic, it is considered highly unlikely that a significant hydrocarbon spill would occur. A hydrocarbon spill risk assessment based on hypothetical spill scenarios was undertaken for the previous Browse FLNG development concept. The results of that assessment have been used to inform this assessment. *Cetaceans* Cetaceans surface to breathe and are therefore, vulnerable to exposure to hydrocarbons when inadvertently surfacing through a slick on the sea surface. Entrained hydrocarbons resulting from a condensate could also result is exposure to cetaceans. This may result in injury or irritation of the eyes, airways and lungs and other body cavities; and at very high concentrations may lead to death as a result of loss of consciousness leading to drowning. Ingested hydrocarbons may also have lethal or sublethal effects including injury to the digestive tract and damage to internal organs. Given cetaceans including listed threatened species pygmy blue whale and humpback whale may occur in the area in low numbers there is some limited potential for them to be impacted in event of a significant release of hydrocarbons. *Marine Turtles* Depending on the seasonal timing of a significant hydrocarbon release, there is potential for significant impacts to green turtles and hawksbill turtles nesting at Scott Reef. Short-term impacts could include significant mortality amongst adults and hatchlings and reduced egg survival. Sublethal stress to individuals may also reduce breeding and nesting success. There is therefore potential for longer-term effects on the population of green turtles nesting at Sandy Islet through mortality of breeding adults and loss of recruitment in the event of a significant hydrocarbon	Refer to **Table 15** for preliminary management measures relating to the prevention of and response to significant hydrocarbon spills.	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
				release. As the breeding population at Scott Reef forms part of a limited genetic stock that is geographically isolated this could have implications for recovery time of the population depending on the extent of impacts. *Seabirds* Seabirds and shorebirds are particularly vulnerable to hydrocarbon spills owing to their high potential for exposure with the sea surface or shoreline where they feed, rest or moult. While there is potential for lethal impacts to individual seabirds, mass mortalities affecting a significant portion of bird populations are considered unlikely given the reported low density of seabirds in the offshore open waters of the Project area and as Sandy Islet does not support major seabird breeding colonies.		
			Risk 10: Underwater Noise – Due to requirement for pile driving	Data from surveys undertaken by Woodside in 2014 has been analysed and further demonstrate that suction piling for moorings should be feasible and therefore suction piling remains the preferred and most likely option for pile installation. In the unlikely event that suction piling at a location is unfeasible, an alternative method will be required to secure moorings. Options include drilling and cementing or impact piling, which involves the application of force to drive piles into the seabed. Underwater noise associated with drill and cement piling would be expected to produce low intensity continuous noise, similar to that generated by drill rigs. Higher noise levels would be associated with impact piling, with typical levels between 200 and 250 dB re 1 µPa at 1m (peak) for a broad range of piles up to 5 m in diameter (McHugh *et al*. 2005; Nedwell and Howell 2004; Talisman 2005; Parvin and Nedwell 2006; Bailey *et al*. 2010). Active driving time for each pile would be expected to take between one and six hours within a 24-hour period, depending on environmental conditions, which would limit potential cumulative exposure of marine fauna to piling noise. In addition, in the event that impact piling is required noise management procedures will be developed and implemented to avoid injury to sensitive marine fauna from underwater noise. These will be detailed in the relevant EPs for submission and acceptance by the relevant regulatory authority. With the addition of the comprehensive noise management procedures that would be implemented to minimise the risk of impact, it is anticipated that driven pile driving would pose a low risk of potential impacts to marine fauna should this option be required.	In the event that impact piling is required for installation of moorings, noise management procedures will be developed and implemented. These will be detailed in the relevant EPs for submission and acceptance by the relevant regulatory authority.	
Listed Migratory Species	An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	Refer to **Section 5.4.1** for details on protected species. **Migratory Species** The following EPBC listed migratory species have been identified as being likely to occur in significant numbers in the vicinity of the Project area and/or interact with the Proposed Action: *Birds* • White-tailed Tropicbird • Red-tailed Tropicbird • Little Tern	The aspects resulting from planned and routine activities and an assessment of the predicted environmental impact is provided above and in **Section 6.2.** Aspects that may impact listed migratory species are the same as those that may potentially impact listed threatened species. Likewise, the impact from and likelihood of risk events are the same for listed migratory species as for listed threatened species. As such, potential impacts to migratory species that are also listed threatened species are address above and are not considered here. *Birds* The potential impact to the white-tailed tropicbird and the red-tailed tropic bird is considerably less than for listed threatened birds as they are only known to occur in the vicinity of the Project area near Rowley Shoals. The little tern is known to occur at Scott Reef which is a known BIA as a resting area for the species. Potential impacts to the little tern are expected to be similar to that as the threatened		Refer to **Table 15**.	**Environmental Impact from Planned and Routine Activities** Based on the predicted impacts of the planned and routine activities and the relevant significance criteria, it is considered highly unlikely that the Proposed Action will have a significant impact on listed migratory species as a result of planned and routine activities.

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment	Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
	• result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	Scott Reef and Rowley shoals are considered BIAs as resting areas for little terns. *Marine Mammals* • Pygmy Blue Whale • Humpback Whale • Bryde's Whale Scott Reef and the surrounding waters have been identified as a possible foraging area (DoE Conservation Management Plan for the Blue Whale) for pygmy blue whales. Refer to **Section 5.4.2** for details on BIAs in the vicinity of the Project area. *Reptiles* • Green Turtle • Hawksbill Turtle Scott Reef and a portion of the surrounding waters are identified as a BIA as inter nesting areas for green and hawksbill turtles. Sandy Islet on Scott Reef and a 20 km surrounding area has identified as habitat for nesting and inter-nesting critical to the survival of green turtles in the DoEE's Recovery Plan for Marine Turtles 2017-2027. *Sharks and Rays* • Whale shark • Shortfin mako shark • Longfin mako shark A BIA for foraging for Whale Sharks is located approximately 40 km from the BTL route.	seabirds and shorebirds addressed above. As such, potential impacts to migratory birds are not considered to be significant. *Marine Mammals* Potential impacts to pygmy blue whales and humpback whales are addressed above. For other cetacean species, only a small proportion of the population is expected to be found within the Browse Development Area, potential impacts are not considered to be significant. *Reptiles* All migratory reptiles that may occur in the area are also listed threatened species and are addressed above. *Sharks and Rays* Shortfin and longfin mako sharks are wide ranging species that may occur in low number in the Project area. It is considered highly unlikely that any significant impacts would occur to these species as a result of the Proposed Action. Potential impacts to whale sharks are addressed above		**Environmental Risk from Unplanned Event or Incidents** Based on the predicted impacts that could potentially occur as a result of unplanned events or incidents, the likelihood of these events and resultant impacts occurring and the relevant significance criteria, it is considered highly unlikely that the Proposed Action will have a significant impact on listed migratory species as a result of unplanned events or incidents.
The Commonwealth Marine Area	An action is likely to have a significant impact on the environment in a Commonwealth marine area if there is a real chance or possibility that the action will: • result in a known or potential pest species becoming established in the Commonwealth marine area	The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory waters. The marine environment in and around the Project area is described in **Section 5**.	**Planned and Routine Activities** The aspects resulting from planned and routine activities and an assessment of the predicted environmental impact is provided in **Section 6.2**. Each of the risks detailed in **Table 13** could potentially impact some aspect of the Commonwealth Marine Area. However, the significance level of some of these impacts has been assessed as negligible (refer to **Table 13)** and as such are not addressed further here. The aspects that may credibly impact the Commonwealth Marine Area are: • IMP-1: Underwater Noise Emissions • IMP-2: Light Emissions • IMP-3: Physical Presence of Infrastructure • IMP-5: Treated Sewage • IMP-6: Treated Process Water (PW)		**Environmental Impact from Planned and Routine Activities** There are a number of aspects that present an impact which may result in a significant impact to the Commonwealth marine environment. It is considered that the proposed development

<table>
<tr><th>Matter of National Environmental Significance</th><th>Significance Criteria</th><th>Existing Environment</th><th colspan="3">Impact Assessment</th><th>Avoidance, Mitigation and Management Measures</th><th>Significance of Impact (with mitigation measures applied)</th></tr>
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<td></td>
<td>• modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results
• have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution
• result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity; social amenity or human health
• result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected, or
• have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck.</td>
<td>Marine Species & Ecological Communities
Marine species and ecological communities in and around the Project area, including those protected under the EPBC Act are described in Section 5.3 and Section 5.4.
Australian Marine Parks
Table 12 details the Australian Marine Parks in the vicinity of the Project area including their conservation values and approximate distances from the Proposed Action. The following Marine Parks are either intersected by, or lie in close vicinity to the Project area.
• Kimberley Marine Park (intersects)
• Argo-Rowley Terrace Marine Park (intersects)
• Mermaid Reef Marine Park (close vicinity)
The following Marine Parks are located in the region, but not in close vicinity the Project area.
• Ashmore Reef Marine Park
• Cartier Island Marine Park
• Roebuck Marine Park
• Eighty Mile Beach Marine Park
• Dampier Marine Park.
• Montebello Marine Park
• Gasgoyne Marine Park.
Key Ecological Features (KEFs)
A summary of the KEFs located in the North West Marine Region and their distance from the Project area is provided in Table 11.
The following KEFs are either intersected by, or lie in close vicinity to the Project area:
• Continental slope demersal fish communities
• Seringapatam Reef and Commonwealth waters in the Scott Reef complex</td>
<td colspan="3">• IMP-8: Cooling Water
• IMP-12: Drilling Cuttings and Fluids.
Unplanned Events and Incidents
The aspects resulting from unplanned events and incident and an assessment of their risk consequence is provided in Section 6.3.
The following Risk Events would be expected to have the potential to result in negligible or slight impacts on the Commonwealth Marine Area. As such they are considered to have a risk consequence level of slight to minor. Due to the level of potential impact and the likelihood of the Risk Event occurring (either remote, highly unlikely or unlikely) these risk events are not considered significant.
• Risk-3: Utility Water - Unplanned discharge of drain waters containing oil and grease
• Risk-4: Cooling Water - Release of cooling water at levels significant above expected
• Risk-5: Non-Hazardous Inorganic Waste - Unplanned discharge of non-hazardous organic wastes
• Risk-6: Hazardous Waste - Unplanned discharge of hazardous wastes
• Risk-7: Drilling Cutting and Fluids - Distribution and impact of drill cuttings significantly wider than predicted
• Risk-8: Seabed Subsidence - Hydrocarbon removal resulting in seabed subsidence.
Risk Events that are considered to have a risk consequence level of moderate, major or catastrophic due to their potential magnitude or the potential for impacts on a regional scale are:
• Risk-1: Invasive Marine Species - Introduction and establishment of Invasive Marine Species
• Risk-2: Treated Process Water (PW) - Release of treated process water at levels significant above expected levels
• Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill.</td>
<td></td>
<td>can be largely implemented in manner so that these significant impacts are avoided. Further work and assessment is required to confirm these impacts and finalise measures to avoid and reduce these impacts.
Environmental Risk from Unplanned Event or Incidents
Based on the predicted impacts that could potentially occur as a result of unplanned events or incidents, the likelihood of these events and resultant impacts occurring and the relevant significance criteria, it is considered highly unlikely that the Proposed Action will have a significant impact on the Commonwealth Marine Area as a result of unplanned events or incidents.</td>
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<td>IMP-1: Underwater Noise Emissions</td>
<td>The primary receptors with respect to underwater noise emissions are marine fauna including cetaceans, marine turtles and fish. Potential impacts and an assessment of their significance to high value species (e.g. listed threatened and migratory species) from underwater noise emission were assessed to be minor as detailed above.
Underwater water noise emissions resulting from drilling and completion of the wells, wellhead operations; and routine FPSO, vessel and aviation operations may also potentially have a slight behavioural impact on a localised scale on other low or medium value species such as pelagic fish.
Assessment
Based on the above potential impacts (primarily potential impacts to high value species) the overall impact of the Proposed Action on the Commonwealth Marine Area as a result of underwater noise emissions is expected to be Minor.</td>
<td>Refer to Table 15 for preliminary management measures relating to underwater noise emissions.</td>
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<td></td><td></td><td></td>
<td>IMP-2: Artificial Light Emissions</td>
<td>The primary receptors with respect to artificial light emission are marine fauna including marine turtles, seabirds and shorebirds. Potential impacts and an assessment of their significance to high value species (e.g. listed threatened and migratory species) from artificial light emissions were assessed to be minor as detailed above.
Light emissions from MODUs, FPSO and vessels may also potentially have a slight behavioural impact (attraction/repulsion, disorientation) on non-listed seabirds or shorebirds. These impacts area expected to be similar in magnitude to that of the high value species.
Assessment</td>
<td>Refer to Table 15 for preliminary management measures relating to artificial light emissions.</td>
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Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
		• Ancient coastline at 125 m depth contour • Mermaid Reef and Commonwealth waters surrounding Rowley Shoals (the BTL passes close but does not intersect) The following KEFs are located in the region, but not in close vicinity the Project area: • Glomar Shoals • Canyons linking the Argo Abyssal Plain and Scott Plateau • Exmouth Plateau • Ashmore Reef and Cartier Island and surrounding Commonwealth waters • Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula • Carbonate bank and terrace system of the Sahul Shelf • Pinnacles of the Bonaparte Basin • Commonwealth waters adjacent to Ningaloo Reef. *Biological Important Areas* BIAs in the vicinity of the Project area and an assessment of the likelihood that the Proposed Action will interact with them are detailed in **Table 10**. BIAs for the following species are intersected or are in close vicinity of the Project area: • Whale Shark • Hawksbill Turtle • Green Turtle • Pygmy Blue Whale • Little Tern • White-tailed Tropicbird *Heritage Values* **Section 5.6.3** details the places listed on the Commonwealth Heritage List that are located in close proximity to the Project area. These include: • Mermaid Reef - Rowley Shoals • Scott Reef and Surrounds - Commonwealth Area. **Section 5.7.1.1** details the indigenous heritage values in and		Based on the above potential impacts (primarily potential impacts to high value species) the overall impact of the Proposed Action on the Commonwealth Marine Area as a result of light emissions is expected to be Minor.		
			IMP-3: Physical Presence of Infrastructure	The physical presence of the infrastructure is expected to impact the Commonwealth Marine Area during both construction (seabed disturbance) and during operations (permanent subsea infrastructure including the BTL, inter-field spur line and the FPSO facilities with associated petroleum safety zones). *Seabed and Benthic Habitats* Installation of the subsea infrastructure including the BTL and inter-field spur line is expected to result in localised seabed disturbance that that will occur over a short duration. No seabed disturbance will occur to high value habitats including Scott Reef or Rowley Shoals. Once installed, the subsea infrastructure will be permanent feature resulting in loss of benthic habitat and associated biota. Due to the length of the BTL and inter-field spur line, a large area of seabed will be disturbed by its installation. The subsea infrastructure, BTL and inter-field spur line will all be installed in deep water with the seabed not expected to support high value habitat. The impacted habitat is expected to be well represented in the region and as such the impact is not considered to be significant. *Australian Marine Parks* While the subsea infrastructure and FPSO facilities do not intersect any Australian Marine Parks, the BTL intersects the: • Multiple Use Zone (IUCN VI) of the Kimberley Marine Park for a distance of approximately 76 km • Multiple Use Zone (IUCN VI) of the Argo-Rowley Terrace Marine Park for a distance of approximately 82 km. As described above, impacts to the seabed during the BTL installation will be minor and of short duration. Once installed, the BTL is not expected to impact on the values of the values of the marine park. *Key Ecological Features* The subsea infrastructure and the BTL will intersect a number of KEFs, as detailed in **Table 11**. Note that a portion of these KEFs lie within the marine parks. As above, the impacted benthic habitat within the KEFs is not expected to be high value and is well represented in the area. As such, no significant impacts are expected to occur to these KEFs. *Biological Important Areas* While subsea infrastructure (well heads and associated umbilicals) will be installed within BIAs for pygmy blue whales, hawksbill turtles, green turtles, and little terns, the infrastructure will be installed such that there will be no significant impact with these species. *Heritage Values* No infrastructure will be placed on Scott Reef or Mermaid Reef and as such, no impact to the heritage values of these listed heritage places will occur. No impact to known marine archaeology value will occur. *Fisheries*	Refer to **Table 15** for preliminary management measures relating to the physical presence of infrastructure.	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
		around the Project area. No know sites of Aboriginal heritage significance are located close to the Project area. **Section 5.7.1.2** details the marine archaeology values in and around the Project area. These include: • The shipwreck of the Yarra which is located at South Scott Reef. • A wreck that is believed to be that of the English whaler the 'Lively' which was lost when it struck the western edge of Mermaid Reef (approximately 40 km from the BTL route) • The wreck of the Haw Kiet located approximately 35 km from the BTL route. *Fisheries* Commonwealth and State managed fisheries in and around the Project area are detailed in **Section 5.7.2.** Traditional fishing by Indonesian fishers is allowed around Scott Reef under the MoU 74 between the Australian and Indonesian governments. The number of such vessels visiting Scott Reef has reduced significantly over time. *Other Users* Other activities utilising the Commonwealth Marine Area in the vicinity of the Project area include the following. Refer to **Section 5.7.3** for further details of these uses. • Scientific Research • Tourism • Shipping • Industry		Due to the location and depth of the proposed subsea infrastructure, BTL and inter-field spur line, it is not expected that significant impacts to commercial or recreational fishing will occur. While Commonwealth and State managed fisheries exist in the area, reported fishing effort in close proximity to the infrastructure is low. The risk of impact on commercial fisheries is expected to be low, and with the proposed management measures to be implemented, significant impacts on key target species of the NWSTF and their habitats are not expected. Potential impacts to the NWSTF may occur, in areas of the fishery that overlap with the subsea infrastructure and activities associated with the Calliance reservoir. A 500 m petroleum safety zone will be implemented around the drill rig and installation vessels as required under the Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGS Act). Petroleum safety zones associated with the drill rig and installation vessels will be temporary. No impact is expected to occur in relation to traditional Indonesian fishers beyond partial exclusions resulting from the Petroleum Safety Zone. *Other Users* Interference with and exclusion of other users, including scientific research and tourism will occur as a result of the infrastructure, facilities and associated petroleum safety zones. Given the low and infrequent use of the area in relation to other users, this impact is expected to be Slight. *Assessment* Due to the short duration of the construction activities, and the low value of the habitat that the permanent infrastructure will be installed on, the impact of the physical presence of Infrastructure on the Commonwealth Marine Area is expected to be Slight.		
			IMP-5: Treated Sewage	The discharge of sewage and sullage (within regulatory discharge limits) is expected to have a slight impact as a result of near-field nutrient enrichment of surrounding waters in offshore open ocean waters. This may result in a slight impact to the Commonwealth Marine Area.	Refer to **Table 15** for preliminary management measures relating to treated sewage.	
			IMP-6: Treated Process Water (PW)	PW will be discharged to the marine environment (within accepted industry limits). This may include the release of NORMs associated with sand and scale (if produced). Formation water may also be discharged from the MODU in low quantities during well clean-up activities. This discharge is expected to result in minor impact as a result of near-field discharge to surrounding waters within the Commonwealth Marine Area above relevant guidance/ background levels for the duration of the discharge activity. Modelling undertaken in support of the Browse FLNG EIS predicted that the PW plume would disperse to below toxicity threshold concentrations within less than 3 km from the facility. PW emissions from the FPSO facilities are expected to be broadly similar (other than MEG concentrations are likely to be pulsed at high concentrations as opposed to continuous trace concentrations). There is potential for PW volumes and discharge rates to increase during later field life to levels above predicted in the Browse FLNG EIS. Further studies with respect to PW discharge from the FPSO facilities will be undertaken during future phases.	Refer to **Table 15** for preliminary management measures relating to PW.	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
				As PW will be treated to meet defined specifications that meet Woodside and accepted industry standards prior to being discharged overboard; and wave and currents are expected to quickly dilute the discharged PW it is considered that PW discharge will result in a minor impact to the Commonwealth Marine Area.		
			IMP-8: Cooling Water	Cooling water will be discharge to the marine environment from the MODU and support vessels. This discharged cooling water will be of a higher temperature than ambient conditions and may contain contaminants (e.g. chlorine). Modelling undertaken in support of the Browse FLNG EIS predicted that temperatures would return to with 3 degrees of ambient temperature within 190 m of the discharge point in winter and 110 m or less in summer. Modelling also predicted that residual chlorine concentrations in cooling water (0.2ppm) will reduce down-current of the discharge point to threshold concentration (0.002ppm) within 1.4 km or less in winter and within shorter distances in the transitional and summer seasons (1.3 km or less and 1.1 km or less respectively) for 95% of the time. Cooling water emissions from each of the FPSO facilities are expected to be significantly reduced compared to those assessed for Browse FLNG EIS. Further studies with respect to cooling water discharge from the FPSO facilities will be undertaken during future phases. Based on this information, the discharge of cooling water is expected to result in minor, near-field discharge to surrounding waters in the Commonwealth Marine Area above relevant guidance/ background levels for the duration of the activity. The significance of this impact is considered Minor.	Refer to **Table 15** for preliminary management measures relating to Cooling Water.	
			IMP-12: Drilling Cuttings and Fluids	Drilling cuttings and fluids will be discharged during construction (well drilling) activities. Modelling undertaken in support of the previous FLNG Concept predicts that the seabed discharge of drill cuttings from top hole sections of the wells results in no sedimentation on Scott Reef coral habitats. Drilling and completion activities required for this Proposed Action is expected to be broadly similar. Following the discharge of drill cuttings and fluids, the coarser fractions (sand and gravel-sized particles) which comprise the majority of the drill cuttings, will rapidly settle to the seabed. Through the settlement process, a turbid plume will develop and will gradually dilute as it disperses down current and through the water column. Coarser fractions (sand and gravel-sized particles) of both the seabed and surface discharge will rapidly settle to the seabed and have the potential to have lethal and sublethal impacts to sessile benthic marine organisms through burial and clogging of respiratory and feeding apparatus of filter feeding organisms resulting in temporary loss of benthic communities and altered community structure. Sedimentation may also affect the grain size of bottom sediments resulting in changes in benthic community composition. Sediment depositional impacts due to discharge at the seabed will be highly localised to the drilling locations. Given that benthic infauna and epifauna are known to recover relatively quickly and affected areas of the seabed support a low density of common and widespread benthic fauna that are well represented in the region, the impact to the benthic community of deep water soft sediment habitat from drill cuttings discharge at the seabed will be Minor. As detailed in **Section 2.8.4**, large sections of the wells will be drilled using seawater and bentonite clay, which is also inert and hence, non-toxic. Only deeper sections may require NWBF. After treatment, cuttings will only contain 5 to 25% WBF and 5 to 10% NWBF. The toxicity of drill fluids used in drilling operations in Australian waters range from non-toxic to slightly toxic, depending on the test organisms used (APPEA 1998). Chemicals used in the seawater and	Refer to **Table 15** for preliminary management measures relating to Drilling Cuttings and Fluids.	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
				seawater with guar gum sweeps, such as barite and bentonite, are non-toxic and therefore, rated as PLONOR substances (OSPAR 2004). The fluids selected will meet the toxicity rating of 'non-toxic' to slightly toxic' and if NWBF are used, residual fluids will be limited to up to 6.9% by wet weight of base fluid. The potential for toxicity effects to pelagic and benthic organisms will be limited due to rapid dilution to non-toxic concentrations within metres of the release point. *Assessment* Overall the discharge of drill cuttings and fluids is expected to result in slight, localised short term decrease in water quality and slight localised permanent impacts to benthic habitat. The impact to the Commonwealth Marine Area is considered to be Slight.		
			Risk-1: Invasive Marine Species - Introduction and establishment of Invasive Marine Species	The introduction and establishment of IMS could potentially result in moderate, medium term impacts to the Commonwealth Marine Area on a regional scale. However, given the regulatory requirements and planned prevention measures, including the development of an IMS management plan, the likelihood of IMS being introduced and becoming established is considered highly unlikely.	Refer to **Table 15** for preliminary management measures relating to the prevention of the introduction of invasive marine species.	
			Risk-2: Treated Process Water (PW) - Release of treated process water at levels significant above expected levels	Woodside has significant operating experience in relation to the assessment, management and monitoring of PW discharges. This experience, together with the regulatory requirements, planned management measures and distance to Scott Reef means that the chance of a released of PW at levels and for durations that could conceivable result in significant impacts to the Commonwealth Marine Area are considered Remote. It should also be noted that if this risk event was realised, ongoing monitoring would make Woodside aware of the impact resulting in actions to stop the impact occurring. As such, they would be of a short, one-off nature.	Refer to **Table 15** for preliminary management measures relating to the discharge of Treated Process Water.	
			Risk-9: Hydrocarbon Spill- Significant hydrocarbon spill	A significant hydrocarbon release could potentially result in long term contamination of the Commonwealth Marine Area high on a regional scale. The impacts on such an event to listed threatened and migratory fauna is discussed above. Such a spill could potentially occur as a result of loss of well control, subsea loss of control, loss of hydrocarbons from topsides, loss of control from substructure (storage of condensate), loss of containment from export BTL (gas only) or loss of containment from vessel collision. Given the significant engineering and risk mitigation measures to be put in place; and the distance from distant from heavy	Refer to **Table 15** for preliminary management measures relating to the prevention of and response to significant hydrocarbon spills.	

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment		Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
				third-party marine traffic, it is considered highly unlikely that a significant hydrocarbon spill would occur. A hydrocarbon spill risk assessment based on hypothetical spill scenarios was undertaken for the previous Browse FLNG development concept. Based on the extent of the contour maps generated from the modelling of the representative spill scenarios for the Browse FLNG development concept, a number of locations were identified to have the potential to be contacted by hydrocarbons in the event of a spill (zone of consequence). These locations included: • North and South Scott Reef lagoon and flats, Sandy Islet and Seringapatam Reef • Offshore Commonwealth Marine Parks including the Kimberley, Argo-Rowley Terrace, Ashmore and Cartier and Mermaid Reef Commonwealth Marine Parks • State marine parks and reserves including Rowley Shoals (Imperieuse and Clerke Reefs) • Offshore islands, namely Browse and Adele Islands. Such a hydrocarbon spill could potentially result in long term contamination to multiple high value habitats and native species within the Commonwealth Marine Area at levels above standards and on a regional scale. Fauna, benthic habitats and ecosystems would be significantly impacted and significant degradation of water quality and sediment quality would occur. While it is considered highly unlikely that such a spill would occur, a risk rating of high is still applicable due to magnitude, duration and extent of the potential impacts.		
National Heritage Places	An action is likely to have a significant impact on the National Heritage values of a National Heritage place if there is a real chance or possibility that it will cause: • one or more of the National Heritage values to be lost • one or more of the National Heritage values to be degraded or damaged, or • one or more of the National Heritage values to be notably altered, modified, obscured or diminished.	No National Heritage Places occur in close proximity to the Project area.	N/A		N/A	N/A
Ramsar Wetlands of International Importance	An action is likely to have a significant impact on the ecological character of a declared Ramsar wetland if there is a real chance or possibility that it will result in: • areas of the wetland being destroyed or substantially modified • a substantial and measurable change in the hydrological regime of the	No Ramsar Wetlands of International Importance occur in close proximity to the Project area.	N/A		N/A	N/A

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment	Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
	wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland • the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected • a substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health, or • an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.				
World Heritage Properties	An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause: • one or more of the World Heritage values to be lost • one or more of the World Heritage values to be degraded or damaged, or • one or more of the World Heritage values to be notably altered, modified, obscured or diminished.	World Heritage Properties as occur in close proximity to the Project area.	N/A	N/A	N/A
Great Barrier Reef Marine Park	An action will require approval if:	The Proposed Action is not located in the vicinity of the Great Barrier Reef Marine Park.	N/A	N/A	N/A

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment	Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
	• the action is taken in the Great Barrier Reef Marine Park and the action has, will have, or is likely to have a significant impact on the environment, or • the action is taken outside the Great Barrier Reef Marine Park and the action has, will have, or is likely to have a significant impact on the environment in the Great Barrier Reef Marine Park.				
Nuclear Actions	All nuclear actions, as detailed in Section 22 of the Act, should be referred to the Department of the Environment for a decision on whether approval is required. These actions are: • establishing or significantly modifying a nuclear installation or a facility for storing spent nuclear fuel • transporting spent nuclear fuel or radioactive waste products arising from reprocessing; • establishing or significantly modifying a facility for storing radioactive waste products arising from reprocessing • mining or milling uranium ore • establishing or significantly modifying a large-scale disposal facility for radioactive waste • de-commissioning or rehabilitating any facility or area in which an activity described above has been undertaken, or • establishing, significantly modifying, decommissioning or rehabilitating a facility where radioactive materials at or above the activity	The Proposed Action is not a Nuclear Action	N/A	N/A	N/A

Matter of National Environmental Significance	Significance Criteria	Existing Environment	Impact Assessment	Avoidance, Mitigation and Management Measures	Significance of Impact (with mitigation measures applied)
	level specified in regulation 2.02 of the Environment Protection and Biodiversity Conservation Regulations 2000 (EPBC Regulations) are, were, or are proposed to be stored.				

9. Summary of Assessment against WA EPA Objectives

An assessment of the Proposed Action against the relevant WA EPA Objective is provided in **Table 17**.

Table 17 Summary of Assessment against WA EPA Objectives

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
Benthic Communities and Habitats	**Guidance:** Environmental Factor Guideline: Benthic Communities and Habitats. **Objective:** To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.	Refer to **Section 5.3.2** for a description of the benthic communities in and around the Project area. Benthic habitat expected to be disturbed within State waters consist of muddy substrates with epifauna likely limited to deposit-feeders rather than suspension-feeders such as sponges and soft corals. Due to the water depths and lack of hard substrate, no macroalgae, seagrass or coral occur in the Development footprint within State waters. High value benthic habitats occur within State waters in close proximity to the Project area. These are described in **Section 5.2.8.1**(Scott Reef) and **Section 5.2.8.2** (Rowley Shoals).	**Planned and Routine Activities** The aspects resulting from planned and routine activities and an assessment of their potential environmental impact is provided in **Section 6.2**. The aspects that may credibly impact benthic communities and habitats include: • IMP-3: Physical presence of infrastructure • IMP-12: Drilling cuttings and fluids. Note that modelling undertaken in support of the Browse FLNG EIS predicted that the PW plume would disperse to below toxicity threshold concentrations within less than 3 km from the FPSO facility. As such they are unlikely to significantly impact State waters. PW emissions from the FPSO facilities are expected to be broadly similar (other than MEG concentrations are likely to be pulsed at high concentrations as opposed to continuous trace concentrations). There is potential for PW volumes and discharge rates to increase during later field life to levels above predicted in the Browse FLNG EIS. Formation water may also be discharged from the MODU during well clean-up activities. In the event this occurs, only low volumes will be discharged with negligible impacts to State waters. Further studies with respect to PW discharge from the FPSO facilities will be undertaken during future phases. **Unplanned Events and Incidents** The aspects resulting from unplanned events and incident and an assessment of their risk consequence is provided in **Section 6.3**. Each of the aspects resulting from Risk Events detailed in **Table 14** occurring could potentially impact benthic communities and habitats in State waters, although the likelihood of these events occurring is considered either remote, highly unlikely or unlikely. Risk Events that are considered to have a low risk rating due to the low consequence level and low likelihood of occurring include the following and are not considered further here: • Risk-3: Utility Water - unplanned discharge of drain waters containing oil and grease • Risk-4: Cooling Water - release of cooling water at levels significant above expected • Risk-5: Non-hazardous inorganic waste - unplanned discharge of non-hazardous organic wastes • Risk-8: Seabed subsidence - hydrocarbon removal resulting in seabed subsidence. Risk Events that are considered to have a moderate or high rating due to high consequence on benthic communities and habitats in state waters (while still considered unlikely or highly unlikely to occur) include: • Risk-1: Invasive Marine Species - Introduction and establishment of Invasive Marine Species • Risk-2: Treated Process Water (PW) - release of treated process water at levels significant above expected levels • Risk-6: Hazardous Waste - unplanned discharge of hazardous wastes • Risk-7: Drilling Cuttings and Fluid - distribution and impact of drill cuttings significantly wider than predicted • Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill.			Given the low significance impact level of the expected impacts from planned and routine activities to benthic communities and habitats; and the low likelihood of potential risk events occurring resulting in significant impacts; it is considered unlikely that the biological diversity and ecological integrity of benthic habitats will be significantly impacts. As such, it is considered that the EPA's objective for this environment factor will be achieved.
			IMP 3: Physical presence of infrastructure	The physical presence of the infrastructure is expected to impact benthic communities and habitats in State waters during both construction (seabed disturbance) and during operations (permanent subsea infrastructure). Within State waters, approximately 20 ha of deep water sparse benthic habitat consisting primarily of bare sediment may be disturbed for the installation of wellheads and associated umbilicals. These impacts are expected to be on a localised scale. No impact is expected on Scott Reef or Rowley Shoals from the physical presence of infrastructure.	Refer to **Table 15** for preliminary management measures relating to the physical presence of infrastructure.	

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
				As such, the impact to benthic communities and habitats from the physical presence of infrastructure within State waters is expected to be Slight.		
			IMP 12: Drilling cuttings and fluids	Drilling cuttings and fluids will be discharged during construction activities. This is expected to result in slight permanent impacts to benthic habitat around the wellhead. No impact to Scott Reef is expected. As such, the impact to benthic communities and habitats from drilling cuttings and fluids within State waters is expected to be Slight.	Refer to **Table 15** for preliminary management measures relating to drilling cuttings and fluids.	
			Risk 1: Invasive Marine Species (IMS) - Introduction and establishment of Invasive Marine Species	The introduction and establishment of IMS could potentially result in moderate, medium term impacts to benthic communities and habitats including Scott Reef. However, given the regulatory requirements and planned prevention measures, including the development of an IMS management plan, the likelihood of IMS being introduced and becoming established is considered highly unlikely.	Refer to **Table 15** for preliminary management measures relating to the introduction of IMS.	
			Risk-2: Treated Process Water (PW) - release of treated process water at levels significant above expected levels	Discharge of PW to the marine environment at levels significantly higher than expected could potentially impact benthic communities and habitats on Scott Reef. Given the studies that have been under taken into PW discharges and the monitoring and mitigation measures to be implemented, it is considered that the likelihood that discharges of PW at levels sufficient to cause impacts to Scott Reef is remote.	Refer to **Table 15** for preliminary management measures relating to the introduction of PW.	
			Risk-6: Hazardous Waste - unplanned discharge of hazardous wastes	The unplanned discharge of hazardous waste could potentially impact benthic communities and habitats on Scott Reef. The Risk Event could lead to slight short term impacts and is considered unlikely to occur given the mitigation measures in place.	Refer to **Table 15** for preliminary management measures relating to hazardous waste.	
			Risk-7: Drilling Cuttings and Fluid - distribution and impact of drill cuttings significantly wider than predicted	In the event that the distribution of drill cuttings is greater than expected, there is a risk that some cuttings may impact upon Scott Reef benthic communities and habitats. Given the modelling that has been undertaken (in relation to Browse FLNG) and the location of the proposed wells, it is considered unlikely that such impacts would occur.	Refer to **Table 15** for preliminary management measures relating to Drilling Cuttings and Fluids.	
			Risk-9: Hydrocarbon Spill - Significant Hydrocarbon Spill	A significant hydrocarbon release could potentially result in long term contamination of benthic communities and habitats in state waters and on a regional scale. Such a spill could potentially occur as a result of loss of well control, subsea loss of control, loss of hydrocarbons from topsides, loss of control from substructure (storage of condensate), loss of containment from export BTL (gas only) or loss of containment from vessel collision. Given the significant engineering and risk mitigation measures to be put in place; and the distance from heavy third-party marine traffic, it is considered highly unlikely that a significant hydrocarbon spill would occur. A hydrocarbon spill risk assessment based on hypothetical spill scenarios was undertaken for the previous Browse FLNG development concept. Scenarios associated with this Proposed	Refer to **Table 15** for preliminary management measures relating to hydrocarbon spills.	

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
				Action would be broadly similar as previously modelled. Addition modelling will be undertaken in future phases. Based on the extent of the contour maps generated from the modelling of the representative spill scenarios for the Browse FLNG development concept, several locations were identified to have the potential to be contacted by hydrocarbons in the event of a spill (zone of consequence). These locations included: • North and South Scott Reef lagoon and flats, Sandy Islet and Seringapatam Reef • State marine parks and reserves including Rowley Shoals (Imperieuse and Clerke Reefs) • Offshore islands namely Browse and Adele Islands. Such a hydrocarbon spill could potentially result in long term contamination to multiple high value benthic communities and habitats at levels above standards and on a regional scale, causing significant impacts. While it is considered highly unlikely that such a spill would occur, a risk rating of high is still applicable due to magnitude, duration and extent of the potential impacts.		
Coastal Processes	**Guidance:** Environmental Factor Guideline: Coastal Processes. **Objective:** To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.	A description of Scott Reef is provided in **Section 5.2.8**	Risk-8: Seabed subsidence - hydrocarbon removal resulting in seabed subsidence	Production activities associated with the Proposal, through the extraction of naturally high pressured reservoir fluids, will cause a reduction in the reservoir's pressure, which has the potential to result in compaction of the geological layers leading to gradual low magnitude subsidence at the seabed. Although this is not deemed significant based on the location of the Brecknock and Calliance reservoirs, as the Torosa gas reservoir spans an area approximately 50 km by 15 km, approximately half of which lies beneath Scott Reef, seabed subsidence resulting from extraction of hydrocarbons from the Torosa reservoir has the potential to affect Scott Reef. Woodside has modelled the magnitude of subsidence and associated horizontal movements for the Browse reservoirs as part of the Browse FLNG development concept. Estimates ranged between 2.6 cm and 8.9 cm, with average vertical seafloor movement totalling approximately 5.4 cm over 40 years (0.6 to 2.2 millimetres per year. Average subsidence was predicted to occur over a radius of about 10 km centred on a point in deep water on the eastern side of North Scott Reef. The magnitude of subsidence is predicted to diminish away from this point up to 18 km. Beyond 20 km, the magnitude of subsidence would be virtually nil. This analysis has been peer reviewed by Baker Hughes GMI Geomechanics Services (Baker Hughes 2012) who concluded that the method and supplied data was appropriate. The DoEE sought further independent review by CO2 Geological Storage Solutions Pty Ltd (CGSS) (CGSS 2012) who found that the report conclusions were reasonable. This level of subsidence is considered insignificant compared to the natural variations in sea level and the sea level rises predicted to result from climate change. The impact of subsidence to Scott Reef and Sandy Islet would therefore, be expected to be insignificant or temporarily positive. Based on subsidence resulting in a maximum 8.9 cm increase in water depth, there may be an initial period of increased coral cover on the reef flat and possibly a decrease in the size or height of Sandy Islet during this period. At the end of the Development life,	No management and mitigation measures have been identified that meet the safety and operational requirements for the Browse FLNG Development while reducing the risk of environmental impact from seabed subsidence associated with the development.	Given the low level of subsidence that may occur as a result of the Proposal, it is considered that the EPA Objective for this Environmental Factor will be achieved.

<table>
<tr><th>Environmental Factor</th><th>EPA Guidance and Objective</th><th>Receiving environment</th><th>Aspect / Risk</th><th>Likely Environmental Impacts</th><th>Avoidance, Mitigation and Management Measures</th><th>Environmental Outcome</th></tr>
<tr><td></td><td></td><td></td><td></td><td>the reef would regain its former height in relation to sea level and the coral communities at Scott Reef and Sandy Islet would be expected to return to a state similar to that observed prior to subsidence.</td><td></td><td></td></tr>
<tr><td>Marine Environmental Quality</td><td>Guidance:
Environmental Factor Guideline: Marine Environmental Quality.
Objective:
To maintain the quality of water, sediment and biota so that environmental values are protected.</td><td>A description of the marine environment including within State water in and around the Project area is provided in Section 5.2 including water quality (Section 5.2.4), Sediment Quality (Section 5.2.3). Biota is described in Section 5.2.8.1 (Scott Reef) and Section 5.2.8.2 (Rowley Shoals).</td><td colspan="3">Planned and Routine Activities
The aspects resulting from planned and Routine activities and an assessment of their potential environmental impact is provided in Section 6.2. The aspects that may credibly impact marine environmental quality within State waters include:
• IMP-5: Treated Sewage
• IMP-12: Drilling cuttings and fluids.

Note that modelling undertaken in support of the Browse FLNG EIS predicted that the PW plume would disperse to below toxicity threshold concentrations within less than 3 km from the facility. As such they are unlikely to significantly impact State waters. PW emissions from the FPSO facilities are expected to be broadly similar (other than MEG concentrations are likely to be pulsed at high concentrations as opposed to continuous trace concentrations). There is potential for PW volumes and discharge rates to increase during later field life to levels above predicted in the Browse FLNG EIS. Further studies with respect to PW discharge from the FPSO facilities will be undertaken during future phases.

Unplanned Activities and Events
The aspects resulting from unplanned events and incident and an assessment of their risk consequence is provided in Section 6.3. Each of the aspects resulting from Risk Events detailed in Table 14 occurring could potentially impact marine environmental quality in State waters, although the likelihood of these events occurring is considered either remote, highly unlikely or unlikely.

Relevant Risk Events that are considered to have a low risk rating due to the low consequence level and low likelihood of occurring include the following and are not considered further here:
• Risk-3: Utility Water - unplanned discharge of drain waters containing oil and grease
• Risk-4: Cooling Water - release of cooling water at levels significant above expected
• Risk-5: Non-hazardous inorganic waste - unplanned discharge of non-hazardous organic wastes.

Risk Events that are considered to have a moderate or high rating due to high consequence on marine environmental quality in State waters (while still considered unlikely or highly unlikely to occur) include:
• Risk-1: Invasive Marine Species - Introduction and establishment of Invasive Marine Species
• Risk-2: Treated Process Water (PW) - release of treated process water at levels significant above expected levels
• Risk-6: Hazardous Waste - unplanned discharge of hazardous wastes
• Risk-7: Drilling Cuttings and Fluid - distribution and impact of drill cuttings significantly wider than predicted
• Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill.</td><td>Given the low significance impact level of the expected impacts to marine environmental quality; and the low likelihood of the potential risk events occurring resulting in significant impacts; it is considered unlikely that the quality of water, sediment or biota will be significantly impacts.

As such, it is considered that the EPA’s objective for this environment factor will be achieved.</td></tr>
<tr><td></td><td></td><td></td><td>IMP-5: Treated Sewage</td><td>The discharge of sewage and sullage (within regulatory discharge limits) from construction and support vessels is expected to have a slight impact on water quality as a result of near-field nutrient enrichment of surrounding waters in offshore open ocean waters. This may result in a slight temporary impact to marine environmental quality in State waters.</td><td>Refer to Table 15 for preliminary management measures relating to treated sewage.</td><td></td></tr>
<tr><td></td><td></td><td></td><td>IMP-12: Drilling cuttings and fluids</td><td>Drilling cuttings and fluids will be discharged during construction (well drilling) activities. This is expected to result in slight, short term decreases in water quality on a near field scale. Sedimentation and minor impacts to sediment quality may also occur, however these will only be in the immediate vicinity of the well head and will not impact Scott Reef.</td><td>Refer to Table 15 for preliminary management measures relating to drilling cuttings and fluids.</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Risk-1: Invasive Marine Species (IMS) - Introduction and establishment of</td><td>The introduction and establishment of IMS could potentially result in moderate, medium term impacts to biota within State waters via predation and/or competition.</td><td>Refer to Table 15 for preliminary management measures relating to IMS.</td><td></td></tr>
</table>

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
			Invasive Marine Species	However, given the regulatory requirements and planned prevention measures, including the development of an IMS management plan, the likelihood of IMS being introduced and becoming established is considered highly unlikely.		
			Risk-2: Treated Process Water (PW) - release of treated process water at levels significant above expected levels	Discharge of PW to the marine environment at levels significantly higher than expected levels could potentially impact marine environmental quality in State waters around Scott Reef. Given the studies that have been undertaken into PW discharges and the monitoring and mitigation measures to be implemented, it is considered that the likelihood that discharges of PW at levels sufficient to cause significant impacts to marine environmental quality within State waters is remote.	Refer to **Table 15** for preliminary management measures relating to PW.	
			Risk-6: Hazardous Waste - unplanned discharge of hazardous wastes	The unplanned discharge of hazardous waste could potentially impact marine environmental quality within State water surrounding Scott Reef. The Risk Event could lead to slight short term impacts and is considered unlikely to occur given the mitigation measures in place.	Refer to **Table 15** for preliminary management measures relating to hazardous waste.	
			Risk-7: Drilling Cuttings and Fluid - distribution and impact of drill cuttings significantly wider than predicted	In the event that the distribution of drill cuttings is greater than expected, there is a risk that some cuttings may impact upon marine environmental quality (water quality, sediment quality, benthic habitat), including Scott Reef. Given the modelling that has been undertaken (in relation to Browse FLNG) and the location of the proposed wells, it is considered unlikely that such impacts would occur.	Refer to **Table 15** for preliminary management measures relating to drilling cuttings and fluids.	
			Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill	A significant hydrocarbon release could potentially result in long term contamination of the marine environment impacting marine environmental quality in State waters and on a regional scale. Such a spill could potentially occur as a result of loss of well control, subsea loss of control, loss of hydrocarbons from topsides, loss of control from substructure (storage of condensate), loss of containment from export BTL (gas only) or loss of containment from vessel collision. Given the significant engineering and risk mitigation measures to be put in place; and the distance from heavy third-party marine traffic, it is considered highly unlikely that a significant hydrocarbon spill would occur. A hydrocarbon spill risk assessment based on hypothetical spill scenarios was undertaken for the previous Browse FLNG development concept. Based on the extent of the contour maps generated from the modelling of the representative spill scenarios for the Browse FLNG development concept, several State water locations were identified to have the potential to be impacted by hydrocarbons in the event of a spill (zone of consequence). These locations included the marine environment associated with: • North and South Scott Reef lagoon and flats, Sandy Islet and Seringapatam Reef. • State marine parks and reserves including Rowley Shoals (Imperieuse and Clerke Reefs). • Offshore islands namely Browse and Adele Islands. Such a hydrocarbon spill could potentially result in long-term contamination of the marine environment above standards and on a regional scale, causing significant impacts. While it is	Refer to **Table 15** for preliminary management measures relating to hydrocarbon spills.	

<table>
<tr><th>Environmental Factor</th><th>EPA Guidance and Objective</th><th>Receiving environment</th><th>Aspect / Risk</th><th>Likely Environmental Impacts</th><th>Avoidance, Mitigation and Management Measures</th><th>Environmental Outcome</th></tr>
<tr><td></td><td></td><td></td><td></td><td>considered highly unlikely that such a spill would occur, a risk rating of high is still applicable due to magnitude, duration and extent of the potential impacts.</td><td></td><td></td></tr>
<tr><td>Marine Fauna</td><td>Guidance:
Environmental Factor Guideline: Marine Fauna.
Objective:
To protect marine fauna so that biological diversity and ecological integrity are maintained.</td><td>A description of the marine fauna that may be present in State waters in and around the Project area is provided in Section 5.4.</td><td colspan="3">Planned and Routine Activities
The aspects resulting from planned and routine activities and an assessment of their potential environmental impact is provided in Section 6.2. The aspects that may credibly impact marine fauna include:
• IMP-1 Underwater Noise Emissions
• IMP-2 Light Emissions
• IMP-3 Physical Presence of Infrastructure.
• IMP-5: Treated Sewage.
• IMP-7: Cooling water

Note that modelling undertaken in support of the Browse FLNG EIS predicted that the PW plume would disperse to below toxicity threshold concentrations within less than 3 km from the facility. As such they are unlikely to significantly impact State waters. PW emissions from the FPSO facilities are expected to be broadly similar (other than MEG concentrations are likely to be pulsed at high concentrations as opposed to continuous trace concentrations). There is potential for PW volumes and discharge rates to increase during later field life to levels above predicted in the Browse FLNG EIS. Further studies with respect to PW discharge from the FPSO facilities will be undertaken during future phases.

Unplanned Events and Incidents
The aspects resulting from unplanned events and incident and an assessment of their risk consequence is provided in Section 6.3. Each of the aspects resulting from Risk Events detailed in Table 14 occurring could potentially impact marine fauna in State waters, although the likelihood of these events occurring is considered either remote, highly unlikely or unlikely.
The following Risk Events would be expected to have the potential to result in negligible or slight impacts on marine fauna in State waters. As such they are considered to have a risk consequence level of Slight to Minor. Due to the level of potential impact and the likelihood of the Risk Event occurring (either remote, highly unlikely or unlikely) these risk events are not considered significant.
• Risk-3: Utility Water - Unplanned discharge of drain waters containing oil and grease
• Risk-4: Cooling Water - Release of cooling water at levels significant above expected
• Risk-5: Non-Hazardous Inorganic Waste - Unplanned discharge of non-hazardous organic wastes
• Risk-6: Hazardous Waste - Unplanned discharge of hazardous wastes
• Risk-7: Drilling Cutting and Fluids - Distribution and impact of drill cuttings significantly wider than predicted
• Risk-8: Seabed Subsidence - Hydrocarbon removal resulting in seabed subsidence.
Risk Events that are considered to have a risk consequence level of moderate, major or catastrophic due to their potential magnitude or the potential for impacts on marine fauna on a regional scale are:
• Risk-1: Invasive Marine Species - Introduction and establishment of Invasive Marine Species
• Risk-2: Treated Process Water (PW) - Release of treated process water at levels significant above expected levels
• Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill
• Risk-10: Underwater noise – Pile driving in the event preferred method of suction piling is not feasible.</td><td>Given the low significance impact level of the expected impacts to marine fauna; and the low likelihood of the potential risk events occurring resulting in significant impacts; it is considered unlikely that marine fauna will be significantly impacted.
As such, it is considered that the EPA’s objective for this environment factor will be achieved.</td></tr>
<tr><td></td><td></td><td></td><td>IMP-1: Underwater Noise Emissions</td><td>Underwater water noise emissions resulting from drilling of the wells, wellhead operations; and routine FPSO, vessel and aviation operations may potentially have a slight behavioural impact on listed threatened cetaceans, marine turtles and fish/sharks. These impacts would be expected to occur on a near field scale.
Cetaceans
The Browse Development Area is identified as a possible foraging area (Blue whale Conservation Plan) for endangered pygmy blue whales although evidence suggests that Scott Reef may only be utilised for opportunistic foraging by pygmy blue</td><td>Refer to Table 15 for preliminary management measures relating to underwater noise emissions.</td><td></td></tr>
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Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
				whales during their passage between regular feeding grounds in the south and breeding grounds in the north (**Section** 5.4.4). Given these relatively low numbers of cetaceans that may occasionally occur in the Project area, and that the Project area is not known to provide significant breeding or feeding habitats, only minor impacts are expected to occur, with no long-term effect at population level, as a result of underwater noise emissions from the development. *Marine Turtles* Disruption to turtles from development noise is expected to be minor due to the transient nature of noise from drilling and completion, installation and commissioning activities, and the low levels of noise during the operations phase in proximity to Sandy Islet. The closest well and associated drilling and installation activities in proximity to turtle nesting habitat at Sandy Islet is expected to be approximately 7 km to the east. Due to the depth of water the wells will be located in, no significant impact from the noise from the wellheads is expected. Noise generated during the drilling operations, particularly from the MODU and vessels on DP may result in behavioural impacts (avoidance behaviour) to inter-nesting turtles within the 20 km interesting zone in the green turtle BIA / critical habitat zone and the hawksbill turtle BIA. Given the small number of wells within this zone, this impact will be temporary in nature and is not expected to be significant. It should also be noted that a moored MODU is planned for the drilling of wells post RFSU. Noise emissions from the MODU on DP are not expected to significant impact turtles close to Sandy Islet due to the significant distance from the closest well (7 km). VSP during drilling will also be a source of underwater noise emission. VSP typically uses up to 3 airguns of 250 cubic inches (cu.in) each (total of 750 cu.in)., discharged approximately five times at 20 second intervals, resulting in sound levels of approximately 238 dB re 1 µPa at 1 m (zero to peak pressure level) (Matthews 2012), with frequencies less than 200 Hz. Sound levels are expected to attenuate rapidly to approximately 180 dB re 1 µPa (zero to peak) within 100 m (Matthews 2012). The process is repeated as required for different stations in the well and may take up to 10 hours to complete. Slight behavioural impacts to inter-nesting turtles may occur, however as these emissions will only occur infrequently and for short durations, this impact is not expected to be significant. *Fish, Sharks and Rays* Impacts to fish, sharks and rays are expected to be limited to avoidance behaviour in the immediate vicinity of the underwater noise sources. Given that relatively low numbers of whale sharks are expected to occur in the vicinity of development activities, and the Project area is not known to provide significant breeding or feeding habitats, only minor impacts are expected to occur to Whale Sharks, with no long-term effect at population level, as a result of underwater noise emissions from the development. Assessment		

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
				Based on the above potential impacts it is expected that underwater noise emissions will result in a slight impact (behavioural, avoidance) on marine fauna on a near-field scale for duration of activities. The significance of this impact is expected to be Minor.		
			IMP-2: Light Emissions	Light emissions from MODUs, FPSO and vessels may potentially have a slight impact (attraction/repulsion, disorientation) on marine turtles and seabirds/shorebirds. Green turtles in the vicinity of Scott Reef, in particular nesting female green turtles at Sandy Islet, have been identified as the main ecological receptor to light emissions associated with the Development. *Marine Turtles* Light studies undertaken in support of the previous Browse FLNG development concept indicate that direct light levels from operations lighting reaching Sandy Islet from the closest MODU and FPSO are likely to be less than 0.01 lux, with light appearing as a small lit object. Therefore, no disturbance to the nesting behaviour of adult marine turtles is expected from light visible at Sandy Islet. Similarly, hatchlings are unlikely to be disorientated by or attracted to such a light source. It should also be noted that Sandy Islet is a small, low-lying sandy cay with nearby access to the water from all directions. Inter-nesting turtles or turtles passing through the Project area may temporarily alter their normal behaviour whilst attracted to the light spill from infrastructure (Light spill of at least 0.01 Lux (i.e. at least quarter moon levels) is likely to extend 1.2 km radially from the MODU and 15 km radially from FPSO facilities. Given their low density presence within the Project area, the zone of influence and subsequent attraction from direct lighting is expected to be minor and a temporary disruption to a small portion of the adult turtle population and are not considered significant. Flaring from the MODUs and FPSO create temporary light sources at levels above normal operating levels. Based on line of sight assessments undertaken for the previous FLNG concept, flaring from the Calliance/Brecknock FPSO may be visible at portions of Scott Reef (depending on the location of the FPSO). Flaring from the Torosa FPSO and the MODU drilling Torosa wells would be visible at all locations on Scott Reef. However, flaring from the FPSO will not be continuous and will likely only occur for short durations during commissioning, start up and shut down. As such these emissions are not expected to result in significant impacts to turtles at Scott Reef. *Seabirds/Shorebirds* Light from the MODU and FPSO facilities is unlikely to attract a significant number of seabirds or shorebirds as activities are located a considerable distance from known key aggregation areas. As per the above discussion, birds roosting at night on Sandy Islet are unlikely to be disturbed given the low level of artificial light from operational lighting (less than 0.01 Lux) that would be received at Sandy Islet.	Refer to **Table 15** for preliminary management measures relating to artificial light emissions.	

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
				The short term and infrequent nature of flaring is unlikely to impact nesting or resting seabirds/shorebird on Scott Reef. Assessment Based on the above potential impacts, it is expected that artificial light emissions will result in a slight impact (attraction/repulsion, disorientation) on certain marine fauna species on a near-field scale for duration of the activities. The significance of this impact on listed threatened species is expected to be Minor.		
			IMP-3: Physical Presence of Infrastructure.	All permanent infrastructure within State waters will be located on the seabed and as such, its presence is not expected to impact marine fauna. Impacts may occur as a result of interaction between construction vessel and individuals, however these are not expected to occur often and will mainly result in avoidance behaviour. Impacts from the physical presence of infrastructure on marine fauna are expected to be Slight.	Refer to **Table 15** for preliminary management measures relating to the physical presence of infrastructure.	
			IMP-5: Treated Sewage	The discharge of sewage and sullage (within regulatory discharge limits) from construction and support vessels is expected to have a slight impact on water quality as a result of near-field nutrient enrichment of surrounding waters in offshore open ocean waters. This may result in a slight temporary impact to marine fauna in State waters.	Refer to **Table 15** for preliminary management measures relating to treated sewage.	
			IMP-8: Cooling Water	Cooling water will be discharge to the marine environment from the FPSO, MODU and support vessels. This discharged cooling water will be of a higher temperature than ambient conditions and may contain contaminants (e.g. chlorine). Based on modelling undertaken for Browse FLNG it is considered that impacts from cooling water would be minor.	Refer to **Table 15** for preliminary management measures relating to Cooling Water.	
			Risk-1: Invasive Marine Species (IMS) - Introduction and establishment of Invasive Marine Species	The introduction and establishment of IMS could potentially result in moderate, medium term impacts to habitat and marine fauna species on a regional scale. However, given the regulatory requirements and planned prevention measures, including the development of an IMS management plan, the likelihood of IMS being introduced and becoming established is considered highly unlikely.	Refer to **Table 15** for preliminary management measures relating to the prevention of the introduction of invasive marine species.	
			Risk-2: Treated Process Water (PW) - Release of treated process water at levels significant above expected levels	Woodside has significant operating experience in relation to the assessment, management and monitoring of PW discharges. This experience, together with the regulatory requirements, planned management measures and distance to State waters means that the chance of a released of PW at levels and for durations that could conceivable result in significant impacts to fauna within State waters is considered remote.	Refer to **Table 15** for preliminary management measures relating to the discharge of Treated Process Water.	
			Risk-9: Hydrocarbon Spill - Significant hydrocarbon spill Cetaceans surface to breathe and are therefore, vulnerable to exposure to hydrocarbons when inadvertently surfacing	A significant hydrocarbon release could potentially result in long term contamination of high value habitat on a regional scale with subsequent lethal and sub-lethal impacts to marine fauna. Given the significant engineering and risk mitigation measures to be put in place; and the distance from distant from heavy	Refer to **Table 15** for preliminary management measures relating to the prevention of and response to significant hydrocarbon spills.	

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
			through a slick on the sea surface. Entrained hydrocarbons resulting from a condensate could also result is exposure to cetaceans. This may result in injury or irritation of the eyes, airways and lungs and other body cavities; and at very high concentrations may lead to death as a result of loss of consciousness leading to drowning. Ingested hydrocarbons may also have lethal or sublethal effects including injury to the digestive tract and damage to internal organs. Given cetaceans including listed threatened species pygmy blue whale and humpback whale may occur in the area in low numbers there is some limited potential for them to be impacted in event of a significant release of hydrocarbons.	third-party marine traffic, it is considered highly unlikely that a significant hydrocarbon spill would occur. A hydrocarbon spill risk assessment based on hypothetical spill scenarios was undertaken for the previous Browse FLNG development concept. The results of that assessment have been used to inform this assessment. *Cetaceans* Cetaceans surface to breathe and are therefore vulnerable to exposure to hydrocarbons when inadvertently surfacing through a slick on the sea surface. This may result in injury or irritation of the eyes, airways and lungs and other body cavities; and at very high concentrations may lead to death as a result of loss of consciousness leading to drowning. Ingested hydrocarbons may also have lethal or sublethal effects including injury to the digestive tract and damage to internal organs. *Marine Turtles* Depending on the seasonal timing of a significant hydrocarbon release, there is potential for significant impacts to green turtles breeding at Scott Reef. Short-term impacts could include significant mortality amongst adults and hatchlings and reduced egg survival. Sublethal stress to individuals may also reduce breeding and nesting success. There is therefore, potential for longer-term effects on the population of green turtles and hawksbill turtle nesting at Sandy Islet through mortality of breeding adults and loss of recruitment in the event of a significant hydrocarbon release. As the breeding population at Scott Reef forms part of a limited genetic stock that is geographically isolated this could have implications for recovery time of the population depending on the extent of impacts. *Seabirds* Seabirds and shorebirds are particularly vulnerable to hydrocarbon spills owing to their high potential for exposure with the sea surface or shoreline where they feed, rest or moult. While there is potential for lethal impacts to individual seabirds, mass mortalities affecting a significant portion of bird populations are considered unlikely given the reported low density of seabirds in the offshore open waters of the Project area and as Sandy Islet does not support major seabird breeding colonies. *Fish* Sub lethal and lethal impacts to fish as a result of a hydrocarbon spill may occur as a result of damage to internal organs from exposure or ingestion of hydrocarbons.		
			Risk 10: Underwater Noise – Due to requirement for pile driving	Data from surveys undertaken by Woodside in 2014 has been analysed and further demonstrate that suction piling for moorings should be feasible and therefore suction piling remains the preferred and most likely option for pile installation. In the unlikely event that suction piling at a location is unfeasible, an alternative method will be required to secure moorings.	Refer to **Table 15** for preliminary management measures relating to underwater noise.	

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
				Options include drilling and cementing or impact piling, which involves the application of force to drive piles into the seabed. Underwater noise associated with drill and cement piling would be expected to produce low intensity continuous noise, similar to that generated by drill rigs. Higher noise levels would be associated with impact piling, with typical levels between 200 and 250 dB re 1 µPa at 1m (peak) for a broad range of piles up to 5 m in diameter (McHugh *et al*. 2005; Nedwell and Howell 2004; Talisman 2005; Parvin and Nedwell 2006; Bailey *et al*. 2010). Active driving time for each pile would be expected to take between one and six hours within a 24-hour period, depending on environmental conditions, which would limit potential cumulative exposure of marine fauna to piling noise. In addition, in the event that impact piling is required noise management procedures will be developed and implemented to avoid injury to sensitive marine fauna from underwater noise. These will be detailed in the relevant EPs for submission and acceptance by the relevant regulatory authority. With the addition of the comprehensive noise management procedures that would be implemented to minimise the risk of impact, it is anticipated that driven pile driving would pose a low risk of potential impacts to marine fauna should this option be required.		
Air Quality	**Guidance:** Environmental Factor Guideline: Air Quality. **Objective:** To maintain air quality and minimise emissions so that environmental values are protected.	The Project area is offshore and remote from urban or industrial areas. Local air quality is therefore not expected to be significantly influenced by anthropogenic sources.	**Planned and Routine Activities** The aspects resulting from planned and routine activities and an assessment of their potential environmental impact is provided in **Section 6.2**. Expected emissions are detailed in **Section 2.8.2**. The aspects that may credibly air quality include: • IMP-4: Gaseous Emissions (Air Emissions and GHGs). **Unplanned Events and Incidents** No risk events (unplanned events or incidents) that could significantly impact air quality have been identified.			Local air quality is not expected to be significantly impacted in State waters and as such it is expected that the EPA objective for this factor will be achieved.
			IMP-4: Gaseous Emissions	Gaseous emissions, including CO_2, CH_4, SOx, NOx and VOCs, will be produced during all phases of the Development, through operation of diesel generators, fuel gas combustion from gas turbines, venting and flaring. Atmospheric emissions from the Development have the potential to result in a localised reduction in air quality in the immediate vicinity of the release point. Given the low emissions levels, very low background levels of emissions and distance from the emissions sources to the nearest environmental sensitive receptors, it is not anticipated that emissions from the Development will have an impact on any sensitive receptors. Significant GHG emissions from the development are expected at the FPSO, particularly as a result of venting. The design of the facilities will be undertaken in a manner to reduce these emissions to ALARP (refer to **Table 15**). GHG emissions in State waters are associated with MODUs and construction vessels and are predominantly construction related.	Refer to **Table 15** for preliminary management measures relating to gaseous emissions.	

Environmental Factor	EPA Guidance and Objective	Receiving environment	Aspect / Risk	Likely Environmental Impacts	Avoidance, Mitigation and Management Measures	Environmental Outcome
				The development will comply with Australian greenhouse gas requirements, National Greenhouse Energy Reporting Act and the Safeguard Mechanism.		
Social Surroundings	**Guidance:** Environmental Factor Guideline: Social Surrounds. **Objective:** To protect social surroundings from significant harm.	The socio-economic and cultural values of the Project area and surrounding areas are described in **Section 5.7**.		The EPA guidance for the environmental factor – Social Surrounds states that "*for social surroundings to be considered in EIA, there must be a clear link between a proposal or scheme's impact on the physical or biological surroundings and the subsequent impact on a person's aesthetic, cultural, economic or social surroundings*". **Planned and Routine activities** The socio-economic values in and around the Project area relate primarily to the quality of the marine environment including the benthic habitat, water quality and marine fauna. As described above, the EPA environmental objectives for each of these aspects are expected to be met, and as such, no significant impact to the social surroundings is expected to occur. It should also be noted that due to the remote location of the Project area, it is not frequently visited. Specifically: • Limited commercial fishing and no aquaculture occurs in the area • Some scientific activities occur, particularly in relation to Scott Reef. Other than exclusion zones around infrastructure, this activity is not expected to be impacted • Some traditional Indonesian fishing occurs at Scott Reef and Seringapatam Reef. Other than exclusion zones around infrastructure, this activity is not expected to be impacted • Limited tourism (infrequent charter vessels) visit Scott Reef and Rowley Shoals. Other than exclusion zones around infrastructure, this activity is not expected to be impacted • No significant shipping traffic or other industry uses exist near the Project area. With respect to cultural heritage, no aboriginal heritage values exist near the Project area, and while one listed wreck (the Yarra) is located at Scott Reef, the wreck is not expected to be impacted. **Unplanned Events and Incidents** In the event that an unplanned event of incident (a risk event) was to occur, particularly the introduction of IMS or a significant hydrocarbon spill leading to impacts on a regional scale, significant impacts to socio-economic values could occur. In particular, such an event could impact State and Commonwealth fisheries where a major spill would result in the establishment of an exclusion zone around the spill affected area. There would be a temporary prohibition on fishing activities for a period of time and subsequent potential for economic impacts to affected commercial fishing operators. As detailed above, unplanned events or incidents that result in significant impacts to the marine environment (including Scott Reef) are considered highly unlikely to occur.		Given the low significance impact level of the expected impacts to social surroundings; and the low likelihood of the potential risk events occurring resulting in significant impacts; it is considered unlikely that social surroundings will be significantly impacted. As such, it is considered that the EPA's objective for this environment factor will be achieved.

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APPENDIX A – Studies undertaken to support the development of the Browse resource

Organisation	Study Name	Aspect
Asia Pacific Applied Science Associates (APASA)	Browse FLNG Development - Quantitative Spill Risk Assessment	Hydrocarbon spills
AIMS	The Status of Shallow-water Coral and Fish Communities at Scott Reef: 2008	Scott Reef
	Technical Report - Project 3.1 Understanding Water Column and Pelagic Ecosystem Processes Affecting the Lagoon of South Reef, Scott Reef – 2010	
	Annual Report - Project 3.1 Understanding Water Column and Pelagic Ecosystem Processes Affecting the Lagoon of South Reef, Scott Reef – 2010	
	Final Report - Project 3.1. Understanding Water Column and Pelagic Ecosystem Processes Affecting the Lagoon of South Reef, Scott Reef	
	Characterising the Genetic Connectivity and Photobiology of Deep Water Reef Building Corals at South Scott Reef, Western Australia – 2010	
	Long-term Monitoring of Coral and Fish Communities at Scott Reef - 2010	
	Long-term Monitoring of Shallow-water Coral and Fish Communities at Scott Reef – 2013	
	AIMS Expert Opinion on Recovery Trajectories of Coral Communities at Scott Reef – 2014	
	AIMS Expert Opinion: Subsidence of Scott Reef - 2014	
	Migration Patterns of Whale Sharks: A Summary of 15 Satellite Tag Tracks from 2005 to 2008	Whale sharks
Australian Marine Mammal Centre (AMMC)	Field Report - Satellite Tagging of South-bound Female Humpback Whales in the Kimberley Region of Western Australia	Humpback whales

Centre for Marine Science and Technology (CMST) (Curtin University of Technology)	Woodside Kimberley Sea Noise Logger Program, September 2006 to June 2009 - 2011	Underwater noise monitoring and modelling
	Prediction of Underwater Noise Levels Associated with the Operation FLNG Facilities in the Browse Basin - 2014	
Centre for Whale Research (CWR)	Humpback Whale Distribution and Abundance in the Near Shore SW Kimberley During Winter 2008 Using Aerial Surveys - 2008	Cetaceans
	Near-shore Vessel Surveys in the SW Kimberley Region During the Humpback Whale Southern Migration - 2008	
	Mega-Fauna Distribution and Relative Abundance in the Scott Reef and Southwest Kimberley Region During - 2008	
	Cetacean Distribution and Oceanography in the Scott Reef/Browse Basin Project areas - 2008	
Charles Darwin University	Long Term Monitoring of the Marine Turtles of Scott Reef 2010	Marine turtles
CSIRO	Characterising the Seabed Biodiversity and Habitats of the Deep Continental Shelf and Upper Slope off the Kimberly Coast, NW Australia – 2010	Satellite data study of oceanography and plankton
DHI	Browse LNG Development - Large Scale Flows / Oceanographic Currents and their Influence on Environmental Impact Modelling Around Scott Reef - 2009	Liquid waste and drill cuttings modelling
	Browse Environmental Modelling - Upstream EIS Sediment Transport Modelling of Drill Cuttings - 2010	
	Browse FLNG Development - Wastewater Dispersion Modelling - 2014	
Fugro Survey Pty Ltd (Fugro)	Offshore Geophysical Surveys 2006: Volume 2A Browse Basin Survey Results	Hydrographic and geophysical surveys
Gardline Marine Services Pty Ltd (Gardline)	Browse LNG Development Environmental Survey - 2009	Water quality, sediment quality and benthic habitats surveys
JacobsSKM	Light Modelling Study - 2014	Artificial light
J P Kenny Pty Ltd (JP	Channel Pipelines - Pipe Installation and Trenching Study - 2008	Sediment quality survey

Kenny)		
MetOcean Engineers	Preliminary Metocean Conditions for the Browse Development (Prospective Production Facilities / Areas, Pipeline Routes / Shore Crossings and Flow-lines / Seabed Manifolds), Scott Reef Vicinity to Shore - 2005	Metocean data
Murdoch University	Macrozooplankton Survey	Macrozooplankton
RPS Environment and Planning Pty Ltd (RPS)	Marine Megafauna Report - 2009	Marine megafauna
	DFS 17 & DFS 20 MMF 2009 Humpback Whale Survey Report	
	Ecology of Marine Turtles of the Dampier Peninsula and the Lacepede Island Group - 2010	
	Marine Megafauna Study - 2010	
	Humpback Whale Survey Report - 2010	
	Turtle Supplementary Report - 2010	
RPS MetOcean	Study of Meteorological Conditions for the Production Facility for Scott Reef Development - 2007	Metocean conditions
	Detailed Metocean Conditions for the Browse Development - 2008	
Sinclair Knight Merz Ltd (SKM)	Scott Reef IMS - 2008	Nearshore benthic habitat surveys Scott Reef IMS survey Scott Reef turtle monitoring
	Aerial survey of Inshore Marine Megafauna Along the Dampier Peninsula - 2009	
	Scott Reef Green Turtle Satellite Tracking Report - 2011	
URS Australia Pty Ltd (URS)	Report on Environmental Surveys Undertaken at Scott Reef in February 2006	Ecology of Scott Reef
	Scott Reef Environmental Survey 4: ROV Inspection of Deep Habitats in Scott Reef Lagoons - 2007	
	Scott Reef Environmental Survey 5: ROV Inspection of Deep Water Outer Reef Habitats - 2007	
	Scott Reef Environmental Surveys – 2007	
WAM	Marine Biodiversity Survey of Mermaid Reef (Rowley Shoals), Scott and Seringapatam Reef - 2006	Ecology of Mermaid, Scott and Seringapatam Reefs

APPENDIX B - Summary of Potential Presence of EPBC Listed Threatened and / or Migratory Species

Codes:

EPBC Act

CR: Critically endangered species

EN: Endangered species

VU: Vulnerable species

WC Act

IE: Migratory birds protected under an international agreement

P3: Priority 3: Poorly-known species

P4: Priority 4: Rare, Near Threatened and other species in need of monitoring

OS: Other specially protected fauna

CD: Conservation dependent fauna

Species	Status under EPBC Act	Status under WA WC Act	Type of Presence and Assessment of Likelihood of Occurrence in Vicinity of Project area and Interaction with Proposal
irds			
Australian Lesser Noddy (*Anous tenuirostris melanops*)	VU, Marine	EN	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** Recorded at Scott Reef by Smith *et al*. (2004). Likely to occur in Project area in small numbers.
Red Knot (*Calidris canutus*)	EN, Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Curlew Sandpiper (*Calidris ferruginea*)	CR, Migratory, Marine	VU, IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.

Southern Giant-Petrel (*Macronectes giganteus)*	EN	P4	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** Project area outside of northern extent of distribution
Australian Fairy Tern *(Sternula nereis nereis)*	VU	VU	**SPRAT Profile:** Breeding known to occur within area **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Far Eastern Curlew (*Numenius madagascariensis*)	CR, Migratory, Marine	VU, IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Abbott's Booby (*Papasula abbotti*)	EN, Marine		**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** Have been recorded in the Browse Basin in very small numbers (two individuals) (Jenner, 2009). Unlikely to occur in significant numbers in the Project area or interact with the Proposal.
Common Noddy (*Anous stolidus*)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat likely to occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Streaked Shearwater (*Calonectris leucomelas*)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat known to occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Lesser Frigatebird, (*Fregata ariel*)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat known to occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Greater Frigatebird (*Fregata minor*)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat may occur within area.

			Assessment: May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
White-tailed Tropicbird (*Phaethon lepturus*)	Migratory, Marine	IA	**SPRAT Profile:** Breeding likely to occur within area. **Assessment:** May occur in Project area along BTL route near Rowley Shoals.
Red-tailed Tropicbird (*Phaethon rubricauda*)	Migratory, Marine	IA, P4	**SPRAT Profile:** Breeding known to occur within area. **Assessment:** May occur in Project area along BTL route near Rowley Shoals.
Little Tern (*Sternula albifrons*)	Migratory, Marine	IA	**SPRAT Profile:** Congregation or aggregation known to occur within area. **Assessment:** Likely to occur in the Browse Development Area in low numbers. BTL route intersects a BIA near Rowley Shoals.
Red-rumped Swallow (*Cecropis daurica*)	Migratory,	IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May occur at Scott Reef. May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Barn Swallow (*Hirundo rustica*)	Migratory,	IA	**SPRAT Profile:** Species or species habitat known to occur within area. **Assessment:** May occur at Scott Reef. May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Grey Wagtail (*Motacilla cinerea*)	Migratory,	IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment**: Know to occur on Rowley Shoals. May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Yellow Wagtail (*Motacilla flava*)	Migratory,	IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Common Sandpiper (Actitis hypoleucos)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat known to occur within area.

			Assessment: Likely to occur at Scott Reef. May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Sharp-tailed Sandpiper (*Calidris acuminate*)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Pectoral Sandpiper (*Calidris melanotos*)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Osprey (*Pandion haliaetus*)	Migratory, Marine	IA	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May fly over the Project area, however unlikely to occur in significant numbers or interact with the Proposal.
Mammals			
Sei Whale (*Balaenoptera borealis*)	VU, Migratory, Cetacean	EN	**SPRAT Profile:** Foraging, feeding or related behaviour likely to occur within area. **Assessment:** Very infrequently recorded in Australian waters. Unlikely to occur in significant numbers in the Project area.
Pygmy Blue Whale (*Balaenoptera musculus brevicauda*)	EN, Migratory, Cetacean	EN	**SPRAT Profile:** Migration route known to occur within area. **Assessment:** Known to occur in low numbers on a regular basis in the Project area.
Fin Whale (*Balaenoptera physalus*)	VU, Migratory, Cetacean	EN	**SPRAT Profile:** Foraging, feeding or related behaviour likely to occur within area. **Assessment:** Very infrequently recorded in Australian waters. Unlikely to occur in significant numbers in the Project area.
Humpback Whale (*Megaptera novaeangliae)*	VU, Migratory, Cetacean	CD	**SPRAT Profile:** Species or species habitat known to occur. **Assessment:** Have been recorded in the Project area. Occasional transient visitor.

Bryde's Whale (*Balaenoptera edeni*)	Migratory, Cetacean		**SPRAT Profile:** Species or species habitat likely to occur. **Assessment:** Have been recorded in the Project area in low numbers with calls recorded year round on noise loggers at Scott Reef.
Australian Snubfin Dolphin *(Orcaella heinsohni*)	Migratory, Cetacean		**SPRAT Profile:** Species or species habitat may occur. **Assessment:** Unlikely to occur in Project area.
Killer Whale (*Orcinus orca*)	Migratory, Cetacean		**SPRAT Profile:** Species or species habitat may occur. **Assessment:** May transit the Project area, however unlikely to occur in significant numbers.
Sperm Whale (*Physeter microcephalus*)	Migratory, Cetacean	VU	**SPRAT Profile:** Species or species habitat may occur. **Assessment:** May transit the Project area, however unlikely to occur in significant numbers.
Spotted Bottlenose Dolphin *(Tursiops aduncus*)	Migratory, Cetacean		**SPRAT Profile:** Species or species habitat may occur. **Assessment:** May transit the Project area, however unlikely to occur in significant numbers.
Spinner dolphin (*Stenella longirostris*)	Cetacean	P4	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** Commonly found in the Project area particularly near Scott Reef.
Reptiles			
Short-nosed (*Seasnake Aipysurus apraefrontalis*)	CE, Marine	CE	**SPRAT Profile:** Species or species habitat likely to occur within area. **Assessment:** Species has a very restricted in distribution to Ashmore and Hibernia Reefs and has not been recorded at Scott Reef. Unlikely to occur in the Project area.
Loggerhead Turtle (*Caretta caretta)*	EN, Migratory, Marine	EN	**SPRAT Profile:** Foraging, feeding or related behaviour likely to occur within area. **Assessment:** Due to the distance from known nesting grounds at the Muiron Islands and North West Cape it is unlikely that loggerhead turtles will occur within the

			Project area. May occur occasional in the Project area but unlikely to occur in significant numbers.
Green Turtle (*Chelonia mydas)*	VU, Migratory, Marine	VU	**SPRAT Profile:** Foraging, feeding or related behaviour known to occur within area. **Assessment:** Nesting is known to occur at Sandy Inlet at Scott Reef. Known to occur within Project area.
Leatherback Turtle, (*Dermochelys coriacea)*	EN, Migratory, Marine	VU	**SPRAT Profile:** Foraging, feeding or related behaviour likely to occur within area. **Assessment:** Due to the oceanic distribution of the species, it is possible that the leatherback turtle may travel through the Project area. However, there are no recorded nesting sites within Western Australia (Limpus, 2009) they unlikely to occur in significant numbers.
Hawksbill Turtle (*Eretmochelys imbricate)*	VU, Migratory, Marine	VU	**SPRAT Profile:** Foraging, feeding or related behaviour known to occur within area. **Assessment:** Very low levels of nesting (one individual recorded in four years of monitoring) is known to occur at Sandy Inlet at Scott Reef. Known to occur within Development area.
Olive Ridley Turtle (*Lepidochelys olivacea)*	EN, Migratory, Marine	EN	**SPRAT Profile:** Foraging, feeding or related behaviour likely to occur within area. **Assessment:** May occur occasional in the Project area but unlikely to occur in significant numbers.
Flatback Turtle (*Natator depressus)*	VU, Migratory, Marine	VU	**SPRAT Profile:** Congregation or aggregation known to occur within area. **Assessment:** May occur occasional in the Project area but unlikely to occur in significant numbers.
Sharks and Rays			
Grey Nurse Shark (*Carcharias taurus*)	VU	VU	**SPRAT Profile:** Species or species habitat may occur within area. **Assessment:** May occur occasional in the Project area (southern extremity of the BTL route) but unlikely to occur in significant numbers.

Great White Shark (*Carcharodon carcharias*)	VU, Migratory	VU	SPRAT Profile: Species or species habitat may occur within area. **Assessment:** May transit the Project area, however unlikely to occur in significant numbers.
Northern River Shark (*Glyphis garricki*)	EN	P1	SPRAT Profile: Species or species habitat may occur within area. **Assessment:** Not expected to occur in Project area.
Dwarf Sawfish, (*Pristis clavata)*	VU	P1	**SPRAT Profile**: Species or species habitat known to occur within area. **Assessment:** Not expected to occur in Project area due to distance offshore.
Northern Sawfish (*Pristis pristis*)	VU, Migratory	P3	**SPRAT Profile**: Species or species habitat known to occur within area. **Assessment:** Not expected to occur in Project area due to distance offshore.
Green Sawfish (*Pristis zijsron*)	VU, Migratory	VU	SPRAT Profile: Species or species habitat known to occur within area. **Assessment:** Not expected to occur in Project area.
Narrow Sawfish (*Anoxypristis cuspidate*)	Migratory		SPRAT Profile: Species or species habitat known to occur within area. **Assessment:** Not expected to occur in Project area.
Whale Shark (*Rhincodon typus*)	VU, Migratory	OS	SPRAT Profile: Foraging, feeding or related behaviour known to occur within area. **Assessment:** Known to occur in the Project area.
Shortfin Mako (*Isurus oxyrinchus*)	Migratory		SPRAT Profile: Species or species habitat likely to occur within area. **Assessment:** May occur occasional in the Project area but unlikely to occur in significant numbers.
Longfin Mako (*Isurus paucus*)	Migratory		SPRAT Profile: Species or species habitat likely to occur within area. **Assessment:** May occur occasional in the Project area but unlikely to occur in significant numbers.
Reef Manta Ray (*Manta alfredi*)	Migratory		SPRAT Profile: Species or species habitat known to occur within area.

			Assessment: May occur occasional in the Project area but unlikely to occur in significant numbers.
Giant Manta Ray (*Manta birostris*)	Migratory		SPRAT Profile: Species or species habitat likely to occur. **Assessment:** May occur occasional in the Project area but unlikely to occur in significant numbers.

APPENDIX C – Protected Matters Search Tool Report