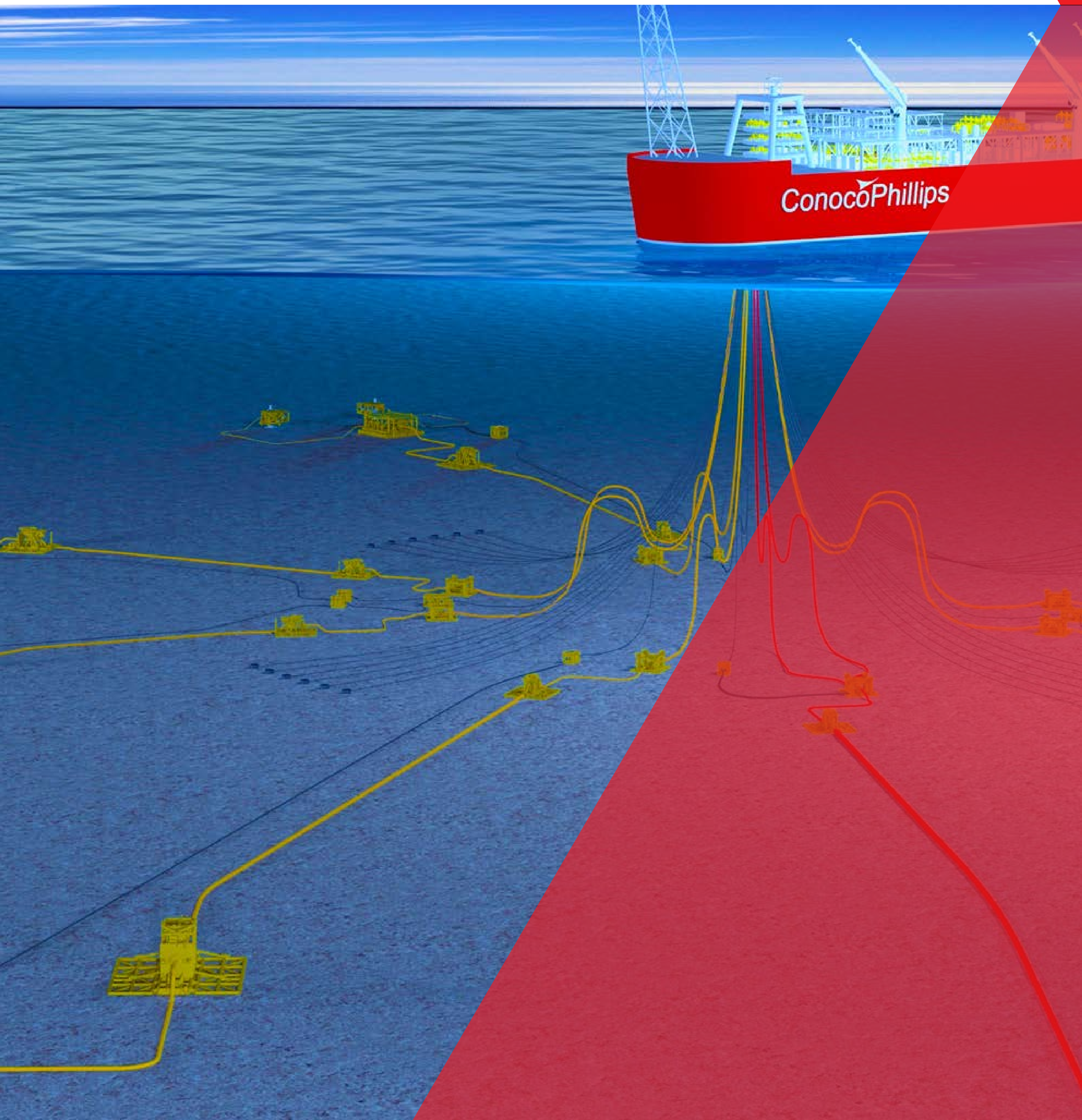
ConocoPhillips
Australia

BAROSSA AREA DEVELOPMENT

OFFSHORE PROJECT PROPOSAL



The Barossa Area Development Offshore Project Proposal (Barossa OPP) has been prepared by ConocoPhillips Australia Exploration Pty Ltd (ConocoPhillips) on behalf of the current co-venturers, SK E&S Australia Pty Ltd and Santos Offshore Pty Ltd, in accordance with the environmental assessment process for a new petroleum project in Commonwealth waters.

The OPP process is regulated by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) and includes opportunity for interested members of the public to comment on the project during its early development stage.

This version of the Barossa OPP has been submitted to NOPSEMA for assessment following an eight week public comment period, 13 July to 6 September 2017.

Acceptance of an OPP does not mean a project can commence. Acceptance will provide approval for ConocoPhillips to submit separate Environment Plans (EPs) for project activities to NOPSEMA for assessment. The EP assessment process will include ongoing consultation with all relevant or interested groups and individuals.

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Contents

Contents

Tables

Figures

Appendices

All appendices cited in the Barossa Area Development Offshore Project Proposal (Barossa OPP) are located in the separate file, *Barossa Area Development Offshore Project Proposal Appendices*, which is also available on NOPSEMA's website,

https://www.nopsema.gov.au/consultation/OPP/3696

Acronyms and abbreviations

°	degrees
$	Australian dollars
%	percent
<	less than
>	greater than
A&OI	Asset and Operating Integrity
ABU	Australian Business Unit
ABU-E	Australian Business Unit-East
ABU-W	Australian Business Unit-West
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHO	Australian Hydrographic Office
AIMS	Australian Institute of Marine Science
ALARP	as low as reasonably practicable
AMAR	autonomous multichannel acoustic recorder
AMP	Australian marine park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
(the) area of influence	The existing environment that may be affected from unplanned activities (e.g. large-scale hydrocarbon release) (**Figure 5-1**)
AS/NZS	Australian Standard/New Zealand Standard
APASA	Asia-Pacific Applied Science Associates
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
AS/NZS	Australian Standard/New Zealand Standard
Barossa offshore development area	Encompasses ConocoPhillips' interests in the Bonaparte Basin (petroleum retention lease NT/RL5 surrounding the Barossa Field, and NT/RL6 surrounding the Caldita Field), the FPSO facility, subsea production system, supporting in-field subsea infrastructure, and marine environment that may be affected by planned discharges (**Figure 4-2**). The area also accommodates the movement of project vessels in the vicinity of the FPSO facility and in-field subsea infrastructure.
Barossa Field	The field in ConocoPhillips petroleum retention lease NT/RL5
BIA	biologically important area
Bio	biodiversity
BoM	Bureau of Meteorology
BOP	blowout preventer
BPPH	benthic primary producer habitat
Bq/L	becquerels per litre
BTEX	benzene, toluene, ethylbenzene and xylenes
BTEXN	benzene, toluene, ethylbenzene, xylenes and naphthalene
BUs	business units
Bus	business
Caldita Field	The field in ConocoPhillips petroleum retention lease NT/RL6
CDU	Charles Darwin University

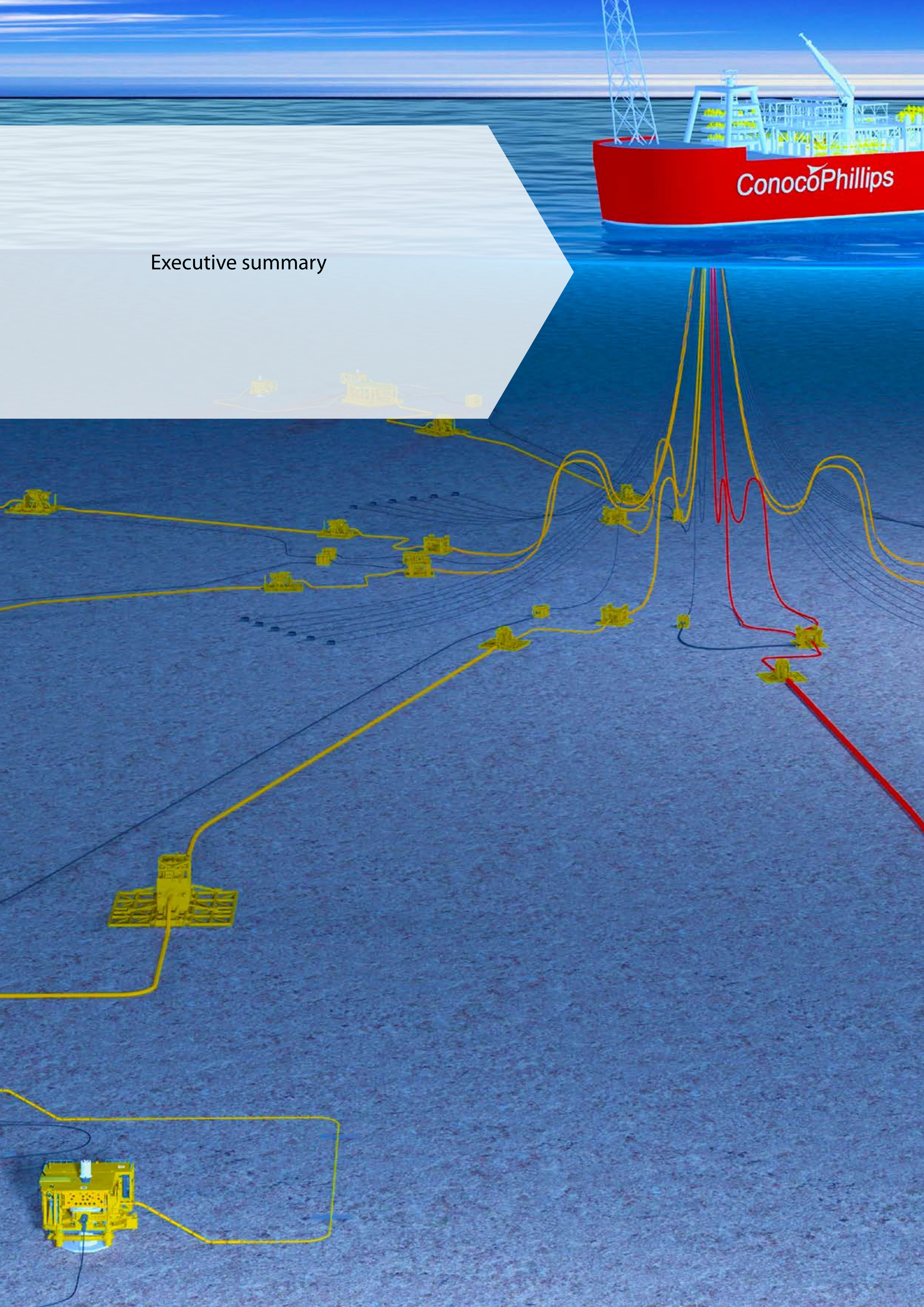
CEE	Consulting Environmental Engineers
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CH_4	methane
CHARM	Chemical Hazard and Risk Management
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalents
COLREGS	International Regulations for Preventing Collisions at Sea 1972
ConocoPhillips	ConocoPhillips Australia Exploration Proprietary Limited
CPF	central processing facility
CPMS	Capital Project Management System
CM&ER	crisis management and emergency response
CMID	Common Marine Inspection Document
CMR	Commonwealth Marine Reserve
CMP	Crisis Management Plan
CMT	Crisis Management Team
CTD	conductivity, temperature and depth
CWR	Centre for Whale Research
dB	decibels
DEC	Department of Environment and Conservation
DEH	Department of Environment and Heritage
DEWHA	Department for the Environment, Water, Heritage and the Arts
DEWNR	Department of Environment, Water and Natural Resources
DFAT	Department of Foreign Affairs and Trade
DIIS	Department of Industry, Innovation and Science
DLNG	Darwin Liquefied Natural Gas
DLRM	Department of Land Resource Management
DME	Department of Mines and Energy
DoA	Department of Agriculture
DoAWR	Department of Agriculture and Water Resources
DoE	Department of the Environment (formerly DSEWPaC)
DoEE	Department of the Environment and Energy (formerly DoE)
DoF	Department of Fisheries (Western Australia)
DPaW	Department of Parks and Wildlife (Western Australia)
DPIF	Department of Primary Industry and Fisheries (Northern Territory)
DPIR	Department of Primary Industry and Resources (Northern Territory)
DPTI	Department of Planning, Transport and Infrastructure
DSD	Department of State Development (Western Australia)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EP	Environment Plan
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPOs	environmental performance outcomes
ERT	Emergency Response Team
ESD	ecologically sustainable development

FEED	front end engineering design
FID	final investment decision
FLET	flowline end terminations
FLNG	floating liquefied natural gas
FPSO	Floating Production, Storage and Offloading
FSO	Floating Storage and Offloading
FTU	Formazin Turbidity Units
GJ	gigajoules
g/m^2	gram per square metre
gas export pipeline corridor	Encompasses the area in which the gas export pipeline will be installed (**Figure 4-3**). A corridor has been defined to allow flexibility and optimisation in design.
GHG	greenhouse gas
ha	hectares
HFO	heavy fuel oil
HSE	health, safety and environment
HSEMS	Health, Safety and Environment Management System
HSE&SD	health, safety, environment and sustainable development
IAFS	International Anti-Fouling Systems
IALA	International Association of Marine Aids Navigation and Lighthouse Authorities
IAPP	International Air Pollution Prevention
IFC	International Finance Corporation
IFO	intermediate fuel oil
ILT	in-line tees
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMDG	International Marine Dangerous Goods Code 1994
IMO	International Maritime Organisation
IMR	inspection, maintenance and repair
IMS	invasive marine species
IMT	Incident Management Team
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organisation for Standardisation
ITF	Indonesian ThroughFlow
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for Conservation of Nature
KEF	key ecological feature
km	kilometre
km^2	square kilometres
L	litre
LC_{50}	Median lethal dose required for mortality of 50% of a tested population after a specified test duration
LNG	Liquefied Natural Gas
Ltd.	Limited
m	metre
m^2	square metres
m^3	cubic metres
m^3/day	cubic metres per day
m/s	metres per second

MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
MEG	mono-ethylene glycol
mg/L	milligrams per litre
MMbbl/yr	million barrels per year
MNES	Matters of National Environmental Significance
MODU	mobile offshore drilling unit
MoU	Memorandum of Understanding
m/s	metres per second
MSDS	material safety data sheet
MSL	mean sea level
Mtpa	million tonnes per annum
N_2O	nitrous oxide
NATO	North Atlantic Treaty Organisation
NAXA	North Australian Exercise Area
NDSMF	Northern Demersal Scalefish Managed Fishery
NEBA	net environmental benefit assessment
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NGER	National Greenhouse and Energy Reporting
NHMRC	National Health and Medical Research Council
nm	nautical miles
NMR	North Marine Region
NOAA	National Oceanic and Atmospheric Administration
NOEC	no observed effect concentration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NORMs	naturally occurring radioactive materials
NO_x	nitrogen oxides
NPI	National Pollutant Inventory
NRETAS	Department of Natural Resources, Environment, The Arts and Sport
NSW	New South Wales
NT	Northern Territory
NTFJA	Northern Territory Fisheries Joint Authority
NTU	nephelometric turbidity units
NTSC	Northern Territory Seafood Council
NWMR	North-west Marine Region
NWSTF	North West Slope Trawl Fishery
OCNS	Offshore Chemical Notification Scheme
ODS	ozone depleting substances
OIW	oil-in-water
OPEP	Oil Pollution Emergency Plan
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPGGS (E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OPP	Offshore Project Proposal
OSMP	Operational and Scientific Monitoring Program
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic

OVID	Offshore Vessel Inspection Database
PAH	polycyclic aromatic hydrocarbon
pers. comm.	personal communication
PK	peak
PLET	pipeline end termination
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
(the) project	The Barossa Area Development, which includes proposed in-field infrastructure in the Barossa Field in petroleum retention lease NT/RL5, accommodating future staged development in the smaller Caldita Field to the south in NT/RL6, and a subsea gas export pipeline connecting the field to tie into the existing Bayu-Undan to Darwin pipeline.
(the) project area	The (collective) Barossa offshore development area and gas export pipeline corridor (**Figure 4-3**)
PTS	permanent threshold shift
PTTEP	PTT Exploration and Production Public Company Limited
Pty	Proprietary
PW	produced water
PWSNT	Parks and Wildlife Service Northern Territory
RO	reverse osmosis
ROV	remotely operated vehicle
SAR	synthetic aperture radar
SBM	synthetic based mud
SBRUVS	stereo baited remote underwater video stations
SD	sustainable development
SEL	sound exposure level
SG	Aanderaa Seaguards
SGG	synthetic greenhouse gases
SKM	Sinclair Knight Merz (now Jacobs)
SMPEP	Shipboard Marine Pollution Emergency Plan
Soc	Socio-cultural and economic
SOLAS	International Convention for the Safety of Life at Sea 1974
SOPEP	Shipboard Oil Pollution Emergency Plan
SOx	sulphur oxide
SPL	sound pressure level
TEG	triethylene glycol
THPS	Tetrakis (hydroxymethyl) phosphonium sulfate
TTS	temporary threshold shift
µg/L	micrograms per litre
µPa	micropascal
UTAs	umbilical termination assemblies
VSP	vertical seismic profiling
w/w	weight per weight
WA	Western Australia
WAF	water accumulated fraction
WAM	Western Australian Museum
WBM	water based mud
WET	whole-of-effluent toxicity
WHP	wellhead platform
WOMP	Well Operations Management Plan

Executive summary



Executive summary

Introduction

ConocoPhillips, as proponent of the Barossa Area Development (herein referred to as 'the project'), on behalf of current and future co-venturers, is proposing to develop hydrocarbon resources in the Timor Sea.

The Barossa offshore development area is within the Bonaparte Basin, approximately 300 km north of Darwin in the Northern Territory (NT) (**Figure ES-1**). The area encompasses petroleum retention lease NT/RL5 and potential future phased development in the smaller Caldita Field to the south in retention lease NT/RL6.

The project development concept includes a Floating Production Storage and Offloading (FPSO) facility, subsea production system, supporting in-field subsea infrastructure and a gas export pipeline, all located in Australian Commonwealth waters. The FPSO facility will separate the natural gas and condensate extracted from the field with the dry gas transported via a gas export pipeline for onshore processing. The condensate will be exported directly from the FPSO to offtake tankers. The new gas export pipeline that will transport the dry gas from the Barossa offshore development area will be approximately 260 km to 290 km long and is proposed to connect to the existing Bayu-Undan to Darwin pipeline in Commonwealth waters (subject to agreeing appropriate commercial arrangements). The new gas export pipeline route is still subject to refinement and therefore a corridor has been identified to allow flexibility at this early stage in the design phase. The project proposes to provide a new source of dry gas to the existing Darwin LNG (DLNG) facility.

The proposed project will develop the large discovered Barossa resource and extend the operating life of the existing DLNG facility, thereby continuing to help meet future global demand for natural gas, and contributing significant income and employment opportunities for Australia. **Table ES-1** provides a summary of key project information.

Table ES-1: Key project information

Proponent	ConocoPhillips Australia Exploration Proprietary Limited (ConocoPhillips)
Location	Barossa offshore development area: Approximately 300 km north of Darwin and approximately 100 km north of the Tiwi Islands Gas export pipeline corridor: Connecting the FPSO facility in the Barossa offshore development area to the existing Bayu-Undan to Darwin pipeline in Commonwealth waters to the south-west of the Tiwi Islands
Water depths	Barossa offshore development area: 130 m–350 m Gas export pipeline corridor: ranging from approximately 30 m to 240 m, , with the exception of a shallow water area (approximately 30 km long) immediately east of the Oceanic Shoals marine park where minimum water depths may be as shallow as approximately 5 m
Development characteristics	• FPSO facility • Subsea production system tied back to the FPSO facility • Gas export pipeline with proposed tie-back connection to the existing Bayu-Undan to Darwin gas export pipeline • Supporting infrastructure for full field development, including fibre optic cable
Anticipated hydrocarbon	Natural gas and light condensate
Approximate Liquefied Natural Gas (LNG) production rate	3.7 million tonnes per annum
Approximate condensate production rate	1.5 million barrels per year
Final investment decision	Target 2019
Operating life	Approximately 25 years
First gas	Target 2023

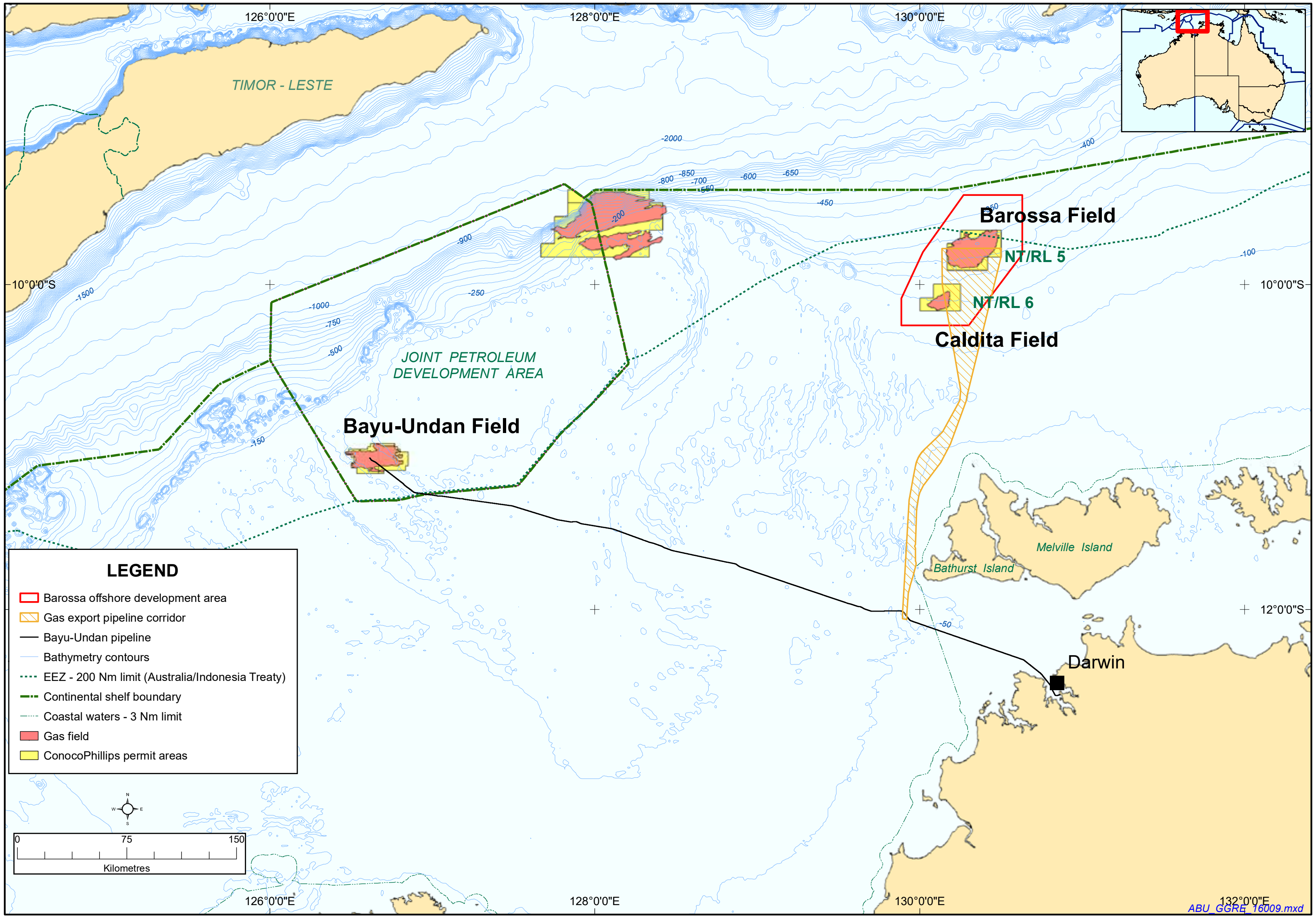


Figure ES-1: Barossa project location

Purpose, structure of document and key legislative requirements

The two main pieces of Commonwealth legislation that apply to the project are the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This Offshore Project Proposal (OPP) has been prepared in accordance with the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regulations), administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), under the OPGGS Act.

The OPP is prepared during a project's early design phase and considers all potential environmental impacts and risks over the project's life-cycle. It provides an assessment of the acceptability of the project at this early stage and will deliver environmental outcomes equivalent to the assessment process under the EPBC Act.

The content and structure of the OPP is outlined in **Figure ES-2**.

The purpose of this OPP, in alignment with NOPSEMA OPP Guidance, is to:

- demonstrate that ConocoPhillips understands the requirements of the OPGGS (E) Regulations
- provide NOPSEMA and other interested stakeholders with the information required to assess the project against the legislative requirements
- identify the nature and scale of potential environmental impacts and risks associated with the project
- define environmental performance outcomes that will allow the impacts and risks to be managed to an acceptable level
- provide the public an opportunity to review and provide input at an early stage of the proposed project.

Acceptance of an OPP by NOPSEMA does not mean a project can proceed. Acceptance provides approval for the subsequent submission of separate Environment Plans (EPs) for project activities to NOPSEMA for assessment and acceptance. EPs include further detail of how the impacts and risks for each activity will be managed to as low as reasonably practicable (ALARP) and acceptable levels. Only after an EP has been accepted by NOPSEMA, can that activity commence.

The EPBC Act includes protection for threatened species, ecological communities or listed places that may be impacted or at risk. The project has considered all relevant management and recovery plans and conservation advices for Matters of National Environmental Significance listed under the EPBC Act and the draft Commonwealth Marine Reserves Network Management Plans. The project will also comply with applicable national and international guidelines and codes of practice.

Any supporting activities within NT jurisdiction are subject to separate permitting arrangements, and as such these approvals are outside the scope of this OPP.

Proponent and environmental governance requirements

Proponent Details

(Section 1.3 and 1.4)

- Overview of ConocoPhillips

Regulation 5A(5)

ConocoPhillips ABU-W Health, Safety and Environmental Management System

(Section 2)

- HSEMS Standard
- Health, Safety and Environment Policy
- Sustainable Development Risk Management Practice
- Capital Project Management System

Regulation 5A(7)

Environmental legislation and other environmental management requirements

(Section 3)

- Commonwealth and Territory legislation
- EPBC Matters of National Environmental Significance Management Plans, Recovery Plans
- International agreements and conventions
- Guidelines and codes of practice

Regulation 5A(7)

Project overview

Description of the project and alternatives analysis

(Section 4)

- Identification and description (nature and scale) of all project, stages, activities and aspects on a "whole of life-cycle" basis
- Assessment of project and activity alternatives

Regulation 5A(5)

Existing baseline environment

Description of the environment

(Section 5)

- Regional overview
- Physical, biological, socio-economic and cultural existing environment, including relevant key values and sensitivities and Matters of National Environmental Significance

Regulation 5A(5) , Regulation 5A(6)

Environmental impacts and risks

Description of environmental impacts and risks

(Section 6)

- Identification of all impacts and risks
- Environmental risk assessment – initial and detailed risk workshops
- Identification of key management controls and systems

Regulation 5A(8)

Environmental performance framework

Implementation strategy

(Section 7.2)

- Overarching management systems, standards and procedures
- Environmental management framework
- Adaptive environmental management

Regulation 5A

Environmental performance outcomes

(Section 7)

- Outcome statements of environmental performance that will be achieved through implementation of key controls throughout the project life
- Demonstration that environmental risks and impacts are manageable to an acceptable level and consistent with the principles of ecologically sustainable development

Regulation 5A(5)

Consultation

(Section 8)

- Open, effective and ongoing consultation throughout the life of the project
- Offshore Project Proposal public comment process

Regulation 5A

(Regulation11A)

Project acceptability

Project acceptability and consistency with the principles of ecologically sustainable development

(Section 7.3 and 7.4)

Regulation 5A

Figure ES-2: Barossa OPP – flowchart of content and structure

Description of the project and alternatives analysis

Definition of the project area and area of influence

The OPP is defined by the following geographical areas, as shown in **Figure ES-3**:

1. the project area, which consists of:
    - the Barossa offshore development area subject to impacts from planned activities
    - the gas export pipeline corridor within which the gas export pipeline route will be located
2. the area of influence, which (based on modelling the worst case credible spill scenarios) is the outer boundary of the environment that may be affected in the highly unlikely event of an unplanned release of hydrocarbons, where no spill response measures are taken.

The Barossa offshore development area encompasses the Barossa and Caldita Fields, the FPSO facility, subsea production system, supporting in-field subsea infrastructure, and marine environment that may be affected by planned discharges. The area also accommodates the movement of project vessels in the vicinity of the FPSO facility and in-field subsea infrastructure. Given the early stage of the project, a buffer has been incorporated into the Barossa offshore development area to allow for flexibility in design and to accommodate potential future expansion. The area directly influenced by the project is expected to be significantly smaller when compared to the overall Barossa offshore development area.

As the location of the gas export pipeline route is subject to further field survey and engineering studies, a pipeline route corridor has been defined in which the physical footprint of the pipeline and project vessel installation or operations activities will occur (**Figure ES-3**). The final selected pipeline route will only comprise a small portion within the pipeline corridor (<0.5%).

In addition to the project area, this OPP considers the potential risks and impacts to environmental values and sensitivities that may be affected from unplanned activities, defined as the 'area of influence'.

Project schedule

The pre-front end engineering design work for the project is currently underway and is anticipated to be followed by FEED in 2018. The final investment decision (FID) for the project is anticipated to be in 2019.

An overview of the notional development schedule is summarised in **Table ES-2**. Timeframes are indicative and may change to reflect adjustments to commercial, contracting and scheduling timelines.

Table ES-2: Barossa project indicative timeframe

Project activity	Target date/timeframe
Development drilling	
Phase 1	Approximately 6 months–2 years post-FID
Phase 2	Approximately 4 years post first gas
Phase(s) 3(+)	During operations (this may include development of the Caldita Field if it is found to be economically viable)
Installation, pre-commissioning and commissioning	
Export pipeline installation (including gas export pipeline infrastructure[1] and fibre optic cable)	Approximate 1–3 years post-FID
In-field subsea infrastructure installation	Approximately 2–4 years post-FID
Tow-out and hook up of the FPSO facility	Approximately 3–5 years post-FID
Commissioning	Approximately 4 years post-FID
Operations	
First gas	Approximately 4–5 years post-FID
Operations	Duration of approximately 25 years post first gas
Decommissioning	Approximately 25 years post first gas

[1] The timing of the tie-in to the existing Bayu-Undan to Darwin gas export pipeline may occur earlier.

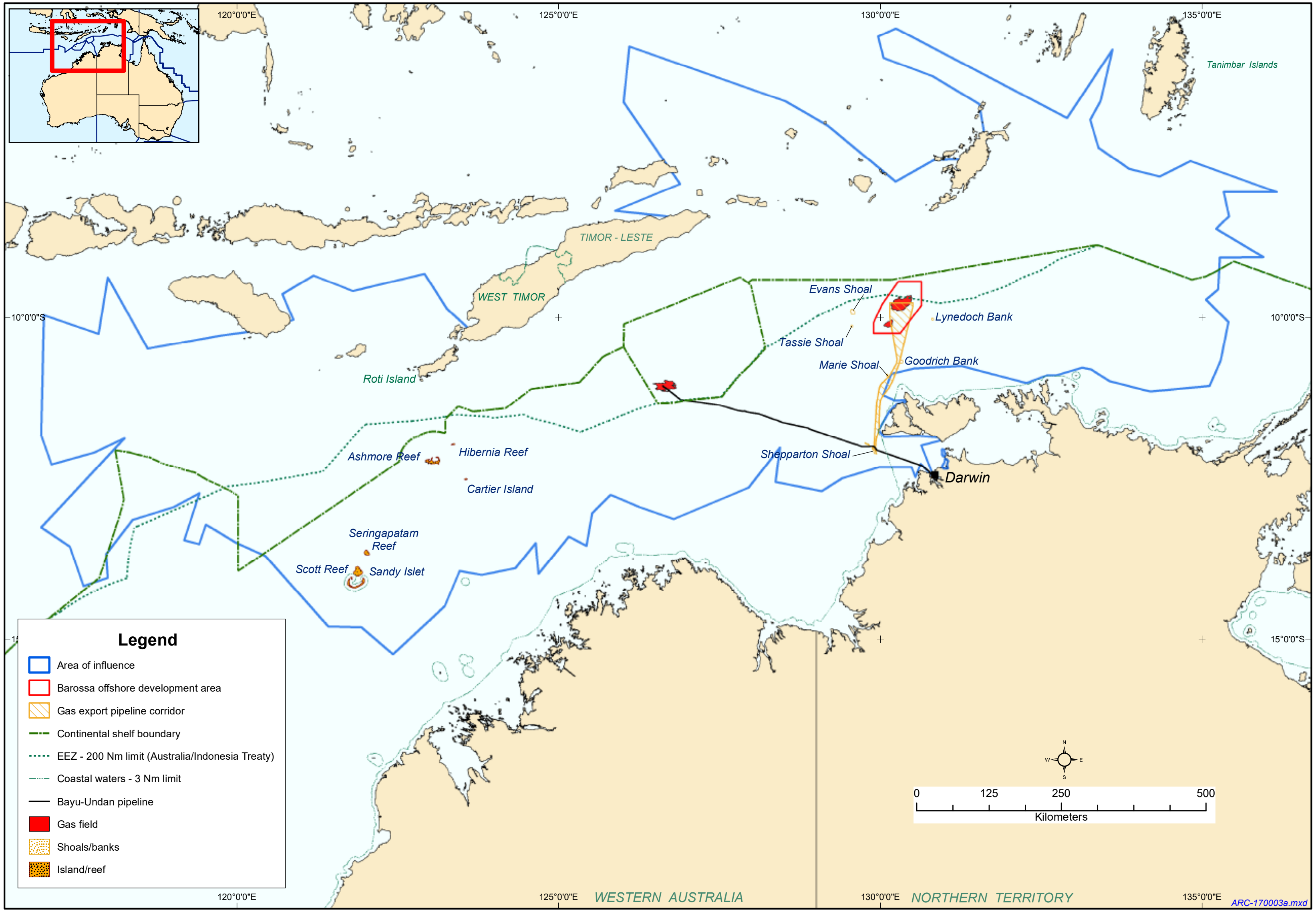


Figure ES-3: Project area and area of influence

Key project facilities and aspects

A brief summary of key project facilities and infrastructure is provided in **Table ES-3,** with the key project stages summarised in **Table ES-4**.

Key environmental aspects associated with the project are:

- physical presence of offshore facilities/infrastructure, equipment and project related vessel movements
- seabed disturbance
- invasive marine species (IMS) (biosecurity)
- underwater noise emissions
- atmospheric emissions
- light emissions
- planned discharges (e.g. drilling fluid and cuttings, produced water, cooling water, wastewater, brine, dewatering of flooding fluid and hydrotest water)
- waste management (e.g. solid/liquid non-hazardous and hazardous waste)
- unplanned discharges (i.e. hydrocarbon and chemicals).

Table ES-3: Project facilities and infrastructure

Physical characteristic	Description
FPSO facility	FPSO facility in the Barossa offshore development area, which collects and processes well fluids, and prepares condensate for direct export and dry gas for transport via a gas export pipeline to the Darwin LNG (DLNG) facility.
In-field umbilicals	In-field umbilicals providing chemicals, power, control signals and monitoring signals will connect the manifolds and subsea wells to the FPSO facility.
In-field subsea infrastructure	Manifolds, flowline end terminations, riser base structures connect flowlines, risers and jumpers together.
In-field flowlines	A production gathering system of flowlines and risers transfer reservoir fluids from the subsea wells to the FPSO facility. Other in-field flowlines may include water, gas and chemical lines. Smaller diameter flowlines or service lines may be used to assist with well start up and reservoir/production management.
Gas export pipeline	A single new gas export pipeline (in the order of approximately 260–290 km in length and 24–26 inches in diameter) proposed to connect the FPSO facility to the existing Bayu-Undan to Darwin gas export pipeline within the defined corridor.
Fibre optic cable	A fibre optic cable connection between the FPSO facility and Darwin may be installed. While the fibre optic cable route is still subject to refinement, the current premise is to follow a broadly similar route to the gas export pipeline, except for the southern end, where it would tie-in to an existing cable infrastructure subject to the selected concept.

Table ES-4: Key project stages

Physical characteristic	Description
Development drilling	The total number of wells is anticipated to be in the order of 10–25 subsea wells. The wells may be drilled using a moored or dynamically positioned semi-submersible mobile offshore drilling unit (MODU) or a drill ship. The approach selected will be influenced by the final well layout.
Subsea infrastructure installation	In-field subsea infrastructure will include wellhead assembly, flowlines, manifolds, umbilicals and risers to connect the subsea wells to the FPSO facility.
Tow-out and hook up of the FPSO facility	The FPSO will be a ship shaped facility, with the hull being either a converted Very Large Crude Carrier, or a new build hull. The processing, storage and offtake (export) facilities (i.e. topside facilities) will all be mounted to the hull.
Commissioning Operations	Planned maintenance of offshore facilities/infrastructure and equipment will be undertaken to confirm continued operability, safety, integrity and environmental compliance.
Gas export pipeline installation	The new gas export pipeline will be 24–26 inches in diameter and installed on the seabed. No permanent surface facilities are required. The gas export pipeline may take between 6 to 12 months to install depending on the amount of seabed preparation required. A range of seabed intervention methods may be used to ensure the pipeline is safely secured on the seabed.
Decommissioning	The project will be decommissioned at the end of its operating life when production from the area is predicted to be no longer economically viable. The project will be decommissioned in accordance with relevant legislation.

Assessment of alternatives

ConocoPhillips evaluated a number of alternative development concepts, including two options with subsea pipeline tie-back to processing facilities at DLNG (an FPSO facility and an offshore fixed jacket platform), a floating LNG facility and 'no development' scenario. Assessment of the different concepts involved consideration of a number of factors including environmental acceptability, technical feasibility, safety, social and heritage, commercial viability, legal requirements and ConocoPhillips' objectives for sustainable and environmentally responsible development.

Two of these concepts, a purpose-built FPSO facility and an offshore fixed jacket facility, were selected for further assessment and subjected to a rigorous and detailed evaluation. The evaluation concluded that an FPSO facility will be safer and more environmentally acceptable. The FPSO concept also has lower capital expenditure cost, increasing the commercial viability of the project which increases the likelihood of securing the capital funding necessary to develop the project and capture the benefits associated with development.

The FLNG development concept was deemed uneconomic early in the project selection process due to its high capital cost relative to options utilising existing infrastructure. The FPSO facility concept will deliver gas supply continuity for the already existing DLNG facility, which not only greatly reduces development costs but importantly also has a significant socio-economic benefit and social investment flow-on effects such as creation of local jobs and supplier opportunities to the Darwin community. Delivering gas from the Barossa offshore development area through the proposed development concept to bring gas to Darwin will enable these socio-economic benefits to continue. The 'no development' scenario was also considered uneconomic, as per the FLNG development concept.

Alternative design features and delivery options as relevant to the project activities are also considered. Of key relevance is the application of a corridor approach to assessing the gas export pipeline given the need to retain flexibility in route selection at this stage of the project. Since the OPP public consultation period, further engineering definition has been undertaken to understand potential pipeline routing and thus, refine the gas export pipeline corridor. Given that draft management plans for the North Australian Marine Parks (AMPs) continue to be developed, the refined pipeline corridor continues to maintain the option to install the gas export pipeline immediately adjacent to the east of the Oceanic Shoals marine park. ConocoPhillips is progressing discussions with Parks Australia regarding the section of the pipeline corridor that transect the proposed Habitat Protection Zone within the Oceanic Shoals Marine Park, as detailed in the Draft North Commonwealth Marine Reserves Network Management Plan. While the draft management plan allows for the construction and operation of a pipeline in the Habitat Protection Zone subject to authorisation from the Director of National Parks, given the process to finalise and adopt the management plan is progressing in parallel to this OPP process, optionality within the corridor is required to be retained at this time. ConocoPhillips is committed to a process to:

- undertake further targeted surveys and engineering review to optimise the gas export pipeline route to minimise environmental impact, while taking into consideration the various environmental values/sensitivities within the defined corridor
- maintain close engagement with Parks Australia regarding the proposal and the key considerations that will determine the viability of route options
- ensure the installation and operations are consistent with the North Commonwealth Marine Reserves Network Management Plan requirements when the plan comes into force, and other legislative requirements relevant to the installation and operation of the pipeline at the time.

Description of the environment

The OPP describes the key physical, biological, socio-economic and cultural characteristics of the existing environment relevant to the proposal, including Matters of National Environmental Significance as defined under the EPBC Act.

Barossa marine studies program

ConocoPhillips has undertaken an extensive and robust environmental baseline studies program, including collaborative studies with the Australian Institute of Marine Science (AIMS), to characterise the existing marine environment within and surrounding the Barossa offshore development area. The baseline studies have involved the rigorous collection of detailed baseline data over 12 months in order to capture seasonal variability and to provide focused data to assist in informing the risk assessment for the project, such that it was relevant to the key environmental values and sensitivities. In addition to providing specific data and information across the project area, the studies collected data used to validate the hydrodynamic model underpinning all discharge modelling studies.

The baseline studies undertaken by ConocoPhillips were preceded by early engagement with key agencies and were informed by a comprehensive literature review and gap analysis. In addition, an advisory panel of recognised experts in specific discipline areas confirmed understanding of values and sensitivities relevant to this OPP assessment.

Key elements of the environment

Physical environment – climate, seabed, air quality, water currents and temperature, water and sediment quality, and underwater noise in the project area are all typical of the region.

Biological environment – there are no significant seabed features or benthic communities in the Barossa offshore development area. The closest regionally important environmental features to the Barossa offshore development area are Evans Shoal (35 km west), Tassie Shoal (32 km west) and Lynedoch Bank (27 km east). Three shoals and banks (Goodrich Bank, Marie Shoal and Shepparton Shoal) are of particular relevance to the gas export pipeline corridor. In the North Marine and North West Marine regions, the most important features are Ashmore Reef (750 km south-west), Cartier Island (735 km south-west), and Seringapatam Reef (960 km south-west) and Scott Reef (970 km south-west).

Marine fauna – there are 20 threatened species and 41 migratory species that may occur in the Barossa offshore development area and gas export pipeline corridor. The Barossa offshore development area has no unique or specific habitats for these marine fauna so, while they may pass through, they will not remain here. There is no land or other features that support nesting or feeding turtles, breeding populations of seabirds, or migratory shorebirds. The Tiwi Islands are about 100 km south of the Barossa offshore development area and about 6 km from the gas export pipeline corridor at its closest point. These islands support several important habitats, nesting sites for marine turtles, seabird rookeries and the conservation of dugongs. Further environmental surveys and engineering studies will be incorporated to finalise the pipeline route.

Socio-economic and cultural environment – there are no heritage properties or wetlands, nor ecological communities requiring specific protection measures in the Barossa offshore development area or gas export pipeline corridor. The gas export pipeline corridor traverses a portion of the Oceanic Shoals marine park, and a portion of the southern end is in close proximity to the Tiwi Islands which hold heritage value for the Indigenous people. There are no known historic shipwrecks within the Barossa offshore development area or the gas export pipeline corridor.

There are a number of fisheries in the region, with five currently active in the project area. Based on consultations to date, ConocoPhillips understand there are no areas of high fishing activity in the vicinity of the project.

Tourism activities such as organised recreational fishing rarely occur in or near the area due to its remote location. These activities are more likely to occur near the southern end of the gas export pipeline, near the Tiwi Islands, where there is also more commercial shipping activity.

More information on these key physical, biological socio-economic and cultural characteristics are provided in **Table ES-5** to **Table ES-7**. The key environmental values and sensitivities of most relevance to the project are shown on **Figure ES-4**.

Table ES-5: Physical characteristics

Physical characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
Climate	✓	✓	• Climate is tropical with a distinct summer monsoonal "wet" season from October to March followed by a typically cooler winter "dry" season from April to September.
Oceanography	✓	✓	• Water movement in the North Marine Region is primarily influenced by wind and tidal activity and less by ocean currents (dominated by the Indonesian Throughflow current system). • Surface water temperatures in the Barossa offshore development area generally ranged between 27°C and 30°C while temperatures above the seabed were approximately 11°C–13°C.
Bathymetry and seabed features	✓	✓	• Water depths in the Barossa offshore development area are between approximately 130 m and 350 m, with the seabed generally flat and devoid of any significant bathymetric features. Marine sediments are predominantly silty sand and lack hard substrate. • Water depths within the gas export pipeline corridor range from approximately 30 m to 240 m, with the exception of a shallow water area (approximately 30 km long) immediately east of the Oceanic Shoals marine park where minimum water depths may be as shallow as approximately 5 m. The seabed along the pipeline corridor varies from relatively smooth and gentle slopes (northern end) to being irregular, as characterised by seabed channels, ridges and mound structures with steep gradients (southern end). Marine sediments range from fine to medium sands/silt and clay (mostly in the northern end) to cemented sediments with rock/reef outcrops (southern end).
Water quality	✓	✓	• Water quality in the Barossa offshore development area is consistent with that of deep-water offshore marine environments and showed minimal variation between seasons, with the exception of the depth of the thermocline. • The majority of metal concentrations were below the Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ) guidelines, with the exception of copper, which was slightly elevated above the guideline concentrations at several sites.

Physical characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
Sediment quality	✓	✓	• Sediments in the Barossa offshore development area were comparable to those observed at a broad regional scale (i.e. in the Eastern Joseph Bonaparte Gulf and Timor Sea). • Gradual transition in sediment composition from the finer deep sediments in the Barossa offshore development area to the coarse gravelly sands in the shallow waters around the shoals/banks. • Levels of metals, total petroleum hydrocarbons and naturally occurring radioactive materials were below the ANZECC & ARMCANZ guidelines, with the exception of the metals, cobalt and nickel.
Air quality and meteorology	✓		• Only very localised and temporary reductions in air quality are associated with offshore shipping and oil and gas exploration/development activities are expected.
Underwater noise	✓	✓	• Natural sources (i.e. wind and waves) of underwater noise dominates the soundscape of the Barossa offshore development area, with some contributions from biological sources (e.g. fish and whales). • There is a low level of anthropogenic activity in the Barossa offshore development area, with vessel movements a minor contributor to noise in the area.

Table ES-6: Biological characteristics

Biological characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
Benthic habitats and communities	✓	✓	• There are no significant areas of benthic habitat in the Barossa offshore development area. The infauna and macrofauna communities and benthic habitat in the project area are known to be uniform and consistent with that associated with deep ocean environments and representative of the broader Bonaparte Basin and Timor Sea. • Based on a benthic habitat model of the Oceanic Shoals marine park developed by AIMS, benthic habitats within the area of the Oceanic Shoals marine park intersected by the gas export pipeline corridor comprise predominantly of burrowers/crinoids, filter feeders and abiotic areas that support no benthic habitat with some small areas of corals and macroalgae. • Based on the AIMS extended benthic habitat model, the majority of the benthic habitats within the pipeline corridor (external to the Oceanic Shoals marine park) are expected to be characterised by filter feeders burrowers/crinoids, with a substantial portion of the area supporting no benthic habitat. Areas of hard and soft coral, macroalgae and gorgonians occur to the west of the Tiwi Islands.

Biological characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
Shoals and banks	✓	✓	• There are a number of submerged shoals and banks in the Timor Sea and open offshore waters, which rise steeply from the surrounding outer continental shelf at depths of 100 m–200 m. • The closest shoals/banks to the Barossa offshore development area are Evans Shoal (approximately 35 km to the west), Tassie Shoal (approximately 32 km to the west) and Lynedoch Bank (approximately 27 km to the east). These shoals/banks support a range of benthic habitats, including macroalgae, filter feeders, corals and sand/rubble, and a diverse range of fish species, including typical reef-fish assemblages, as well as pelagic species. Several sharks and sea snake species were also recorded. The infauna communities were reasonably diverse and abundant. • The shoals/banks located directly adjacent to or within the gas export pipeline corridor, include Goodrich Bank, Marie Shoal and Shepparton Shoal. The results of available information indicate that the ecological characteristics of these shoals and banks are consistent with the characteristics described for Evans Shoal, Tassie Shoal and Lyndoch Bank described above. The shoals/banks within the region all support comparable levels of biodiversity suggesting a high level of interconnectivity (Heyward et al. 2017). Benthic communities surveyed in the Barossa marine studies program showed that neighbouring shoals and banks (i.e. within 100s of km's) frequently share approximately >80% of benthic community composition (Heyward et al. 2017), with variability in many cases attributed to dynamic response to differing cycles of disturbance history such as storms/cyclones or thermal stress events.
Other regional seabed features of interest	✓	✓	• Several seamounts and scarps were identified within or in the vicinity of the Barossa offshore development area. • Some regional seabed features of environmental interest associated with the key ecological feature of the carbonate bank and terrace system of the Van Diemen Rise were identified in the southern section of the gas export pipeline.
Tiwi Islands		✓	• The Tiwi Islands (Melville and Bathurst Islands) are in relatively close proximity to the southern end of the gas export pipeline corridor and occur within the area of influence. • The islands support a number of shoreline habitats, including mangroves, sandy beaches, seagrass meadows and fringing reef habitats, and are an important nesting site for marine turtles. The islands also support significant numbers of seabirds and migratory shorebirds, and a large aggregation of dugongs.
Other offshore reefs and islands		✓	• Offshore reefs and islands in the area of influence include Ashmore Reef, Cartier Island, Hibernia Reef, Seringapatam Reef and Scott Reef. These support coral reef systems and provide important habitat for marine fauna, including species of conservation significance. • Relevant values and sensitivities associated with the Indonesian and Timor-Leste coastlines are considered in **Table ES-7**.

Biological characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
NT and WA mainland coastline		✓	• The NT and WA mainland coastline is only relevant to the project in the context of the area of influence, as some small areas of the coastline may be contacted in the unlikely event of a large-scale unplanned release, with a low probability of occurrence. While spill modelling does not predict contact with the WA coastline, high level consideration has been given to the Kimberley coastline for completeness. • The nearshore and coastal environment of the NT (including the Darwin coast) and WA support a diverse array of marine habitats, communities and marine fauna, including EPBC listed species.
Plankton	✓	✓	• Plankton have a wide and often patchy distribution in marine environments. • Phytoplankton and zooplankton communities in the Barossa offshore development area were relatively similar across the seasons.
Listed threatened and migratory species of conservation significance	✓	✓	• Barossa offshore development area – up to 18 listed threatened fauna species and 29 listed migratory species (17 of which are also listed as threatened species) may occur or have habitat in the area. All species identified in the Barossa offshore development area were also identified in the gas export pipeline corridor. • Gas export pipeline corridor – up to 20 listed threatened fauna species and 41 listed migratory species (18 of which are also listed as threatened species) may occur or have habitat in the area. Two threatened species and 10 migratory species were identified in the pipeline corridor in addition to those identified in the Barossa offshore development area. • Area of influence – up to 29 listed threatened fauna species and 71 listed migratory species (21 of which are also listed as threatened species) may occur or have habitat in the area. • The Barossa offshore development area does not contain any biologically important areas or regionally significant feeding, breeding or aggregation areas for marine fauna. • Marine mammals recorded in the Barossa offshore development area and surrounds during the underwater noise monitoring included pygmy blue whales, Bryde's whales, Omura's whale, unknown beaked whales and odontocete species (toothed whales). • Pygmy blue whales were detected in the Barossa offshore development area between late May and August, during their northward migration. • A small number of individual Bryde's whales were recorded in the Barossa offshore development area from January to early October.

Biological characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
			• The grey nurse shark (listed under the EPBC Act) was recorded at a seamount approximately 18 km west of the Barossa offshore development area during the Barossa marine studies program. • The Barossa offshore development area does not contain any emergent land or shallow features that may be of importance to turtles and, therefore, they are unlikely to be present in the area in significant numbers. However, low numbers are likely to transit the area. • The gas export pipeline corridor traverses internesting habitat critical to the survival of flatback and olive ridley turtles, the biologically important internesting area for flatback turtles and the biologically important area for breeding and foraging for the crested tern (waters offshore of the Tiwi Islands). • Sea snakes are typically distributed in shallow inshore regions and islands, but are also found at nearby islands and further offshore at atolls, including the shoals/banks in the Timor Sea. • There is no emergent land in the project area to support nesting or roosting of seabirds/migratory shorebirds. Therefore, most seabird activity is restricted to foraging, as individuals transit the area. • Fish assemblages in the Barossa offshore development area are likely to support offshore pelagic and demersal fish assemblages, which are typical of those found in the North Marine Region. • The majority of shark and ray species potentially occurring in the project area prefer nearshore environments (e.g. island groups or atolls), coastal water, inshore marine water or tidal river and estuary habitats. However, like sea snakes, they have also been observed around offshore coral reefs, rocky reefs and seamounts.

Table ES-7: Socio-economic and cultural characteristics

Socio-economic and cultural characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
World Heritage properties			• There are no World Heritage properties in the project area or area of influence.
National heritage places		✓	• Ashmore Reef and Cartier Island National Nature Reserve (at least 730 km away) are located within the area of influence.
Commonwealth heritage places		✓	• While significantly distant from the project area, the Seringapatam Reef and Surrounds (960 km to the south-west of the Barossa offshore development area) and Ashmore Reef National Nature Reserve (750 km to the south-west) Heritage places are within the area of influence.

Socio-economic and cultural characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
Declared Ramsar wetlands		✓	• The Ashmore Reef Ramsar wetland is distant from the project area (750 km), while within the area of influence.
Commonwealth marine area	✓	✓	• The Barossa offshore development area and gas export pipeline corridor is located wholly in the Commonwealth marine area, which stretches from three to 200 nautical miles from the coast.
AMPs	✓	✓	• The Barossa offshore development area is not located within any AMPs. • The gas export pipeline corridor traverses the Oceanic Shoals marine park, which covers a large area of 71,743 km^2. The Oceanic Shoals marine park is currently designated under transitional management arrangements as entirely Multiple Use Zone (IUCN category VI). • The area of influence may extend into six AMPs; the Oceanic Shoals, Arafura, Arnhem, Kimberley, Ashmore Reef and Cartier Island AMPs.
Listed threatened communities			• There are no listed threatened communities, as defined under the EPBC Act, within the project area or area of influence.
Key ecological features (KEFs)	✓	✓	• The KEFs of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of the Van Diemen Rise are present within the project area. • In addition, the KEFs of the pinnacles of the Bonaparte Basin, tributary canyons of the Arafura depression, carbonate bank and terrace system of the Sahul Shelf, continental slope demersal fish communities, Ashmore Reef and Cartier Island and surrounding Commonwealth waters, Seringapatam Reef and Commonwealth waters in the Scott Reef complex and ancient coastline at 125 m depth contour are also present within the area of influence.
Commonwealth land		✓	• There is no Commonwealth land within the project area. • Ashmore Reef and Cartier Island (at least 730 km away) are within the area of influence.
Indigenous heritage		✓	• Indigenous heritage values on the Tiwi Islands and Ashmore Reef are relevant to the area of influence.
Marine archaeology	✓	✓	• There are no known shipwreck protected zones or shipwrecks within the project area. • Three historic shipwrecks are located within the area of influence; two steamer ships, one sunk to the north-west and one adjacent to the west coast of Bathurst Island, and a submarine sunk in the Beagle Gulf.

Socio-economic and cultural characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance

Commercial fisheries	✓	✓	• Although several Commonwealth and State managed fisheries overlap the project area, the level of fishing effort is limited in the Barossa offshore development area and within the majority of the gas export pipeline corridor.
			• In total, five Commonwealth, six NT and three WA managed fisheries occur within the project area and area of influence:
			  • Commonwealth: Northern Prawn Fishery, North West Slope Trawl Fishery, Southern Bluefin Tuna Fishery, Western Skipjack Tuna Fishery, and Western Tuna and Billfish Fishery.
			  • NT: Aquarium Fishery, Coastal Line Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery and Timor Reef Fishery.
			  • WA: Mackerel Managed Fishery, Northern Demersal Scalefish Managed Fishery and Northern Shark Fisheries.

Traditional Indigenous fishing	✓	✓	• The majority of the project area is located in remote offshore waters that are unlikely to be regularly accessed by traditional indigenous fishing activities. • A traditional Indonesian fishing area (legally permitted under a Memorandum of Understanding) is established in waters in the vicinity of Scott Reef, Seringapatam Reef, Browse Island, Ashmore Reef and Cartier Island (approximately 720 km to the south-west), which is within the area of influence. • Traditional Indigenous fishing is known to occur in the vicinity of the Tiwi Islands.
Tourism and recreational activities	✓	✓	• Tourism activities, such as organised recreational fishing tours, rarely occur in or near the offshore waters of the Barossa offshore development area and majority of the gas export pipeline corridor due to its remote location. • Tourism and recreational activities are more likely to occur in or near the southern end of the gas export pipeline or area of influence as a number of fishing charters operate in the coastal waters along the NT coastline and in the vicinity of the Melville and Bathurst Islands. These waters are also used by recreational fishers.
Mariculture activities		✓	• The project area is not accessed for aquaculture activities. • Mariculture activities occur in NT coastal waters, which are within the area of influence.
Defence activities		✓	• There are no designated military/defence exercise areas in the project area. • The maritime military zone (North Australian Exercise Area) administered by the Department of Defence is located within the area of influence.

Socio-economic and cultural characteristic	Present in project area	Present in area of influence	Particular values/sensitivities of relevance
Ports and commercial shipping	✓	✓	• The closest major commercial port to the project area is Darwin (approximately 300 km south), with minor port activities at Port Melville primarily servicing Tiwi Island plantation woodchip exports. • The Barossa offshore development area and majority of the gas export pipeline do not overlap any major commercial shipping channels. The southern end of the proposed pipeline is in an area of high shipping traffic due to its proximity to Darwin.
Offshore petroleum exploration and operations		✓	• The closest operational production facilities – the ConocoPhillips Bayu-Undan platform – is approximately 360 km to the west-south-west of the Barossa offshore development area.
Scientific research	✓	✓	• Scientific expeditions and surveys occur on occasion across the broader offshore Timor Sea and Browse Basin.
Indonesian and Timor shorelines		✓	• Indonesian, West-Timor and Timor-Leste shorelines may be affected by the potential scenario of an unplanned hydrocarbon release. • The coastlines and coastal waters support a range of habitats and communities and provide habitat for a number of protected and commercially important species.

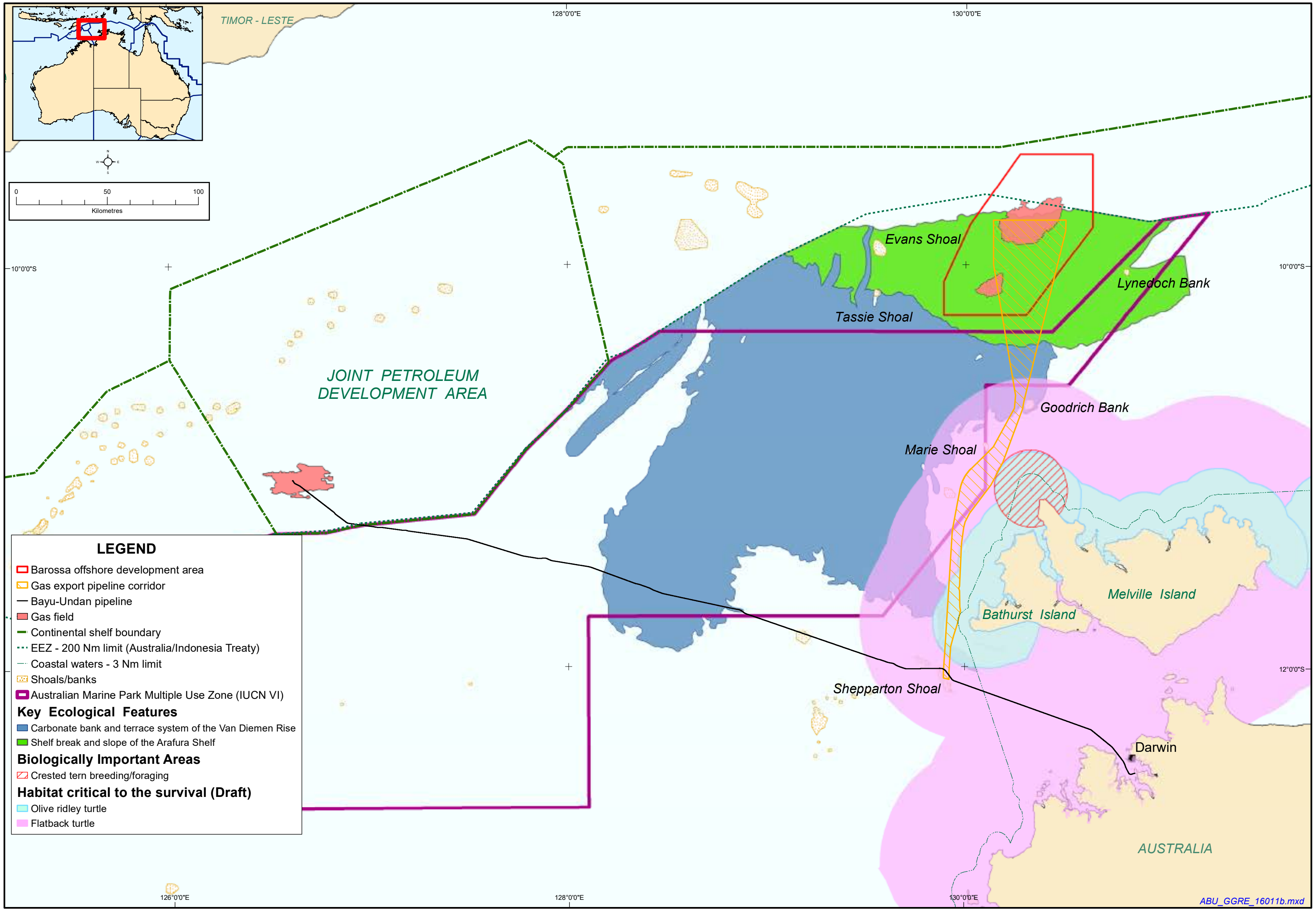


Figure ES-4: Key values and sensitivities of primary relevance to the project

Description of environmental impacts, risks and performance outcomes

The risk assessment process undertaken for the OPP provides an evaluation of all potential impacts and risks identified for the life-cycle of the project at the early design phase. The risk assessment takes into consideration a comprehensive understanding of the existing environment and the nature and scale of each potential impact and risk in the context of what is acceptable given the existing environment. The risk assessment process applied a precautionary approach in terms of defining the 'outer envelope' of possible impacts associated with the project design options. The assessment also encompassed an evaluation of all potential impacts and risks arising directly or indirectly from all future activities and potential emergency conditions. A summary of the risk assessment is provided in **Table ES-8**.

The OPP defines a number of measurable, project specific key management controls and environmental performance outcomes (EPOs) that will be applied to manage the potential environmental impacts and risks associated with the project to ensure they are of an acceptable level and consistent with the principles of ecologically sustainable development (ESD). EPOs for each aspect are presented in **Table ES-8**.

Potential impacts associated with decommissioning will depend upon the chosen strategy to be confirmed nearer the time of decommissioning. A decommissioning EP will be developed prior to commencement of decommissioning activities and will be subject to acceptance by NOPSEMA.

ConocoPhillips is also committed to an ongoing risk assessment process, with potential impacts and risks to be reviewed and further assessed during preparation of any subsequent EPs.

Table ES-8: Project risk assessment summary

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
Physical presence of offshore facilities/ infrastructure, equipment and project related vessels – interactions with other marine users	Commercial fishing. Recreational fishing. Commercial shipping. Offshore petroleum exploration operations.	Interference with and/or exclusion of commercial/ recreational fishing vessels, commercial shipping or other marine users. Business interruption (abnormal) to the activities of other marine users due to damage to commercial vessels or fishing gear. Interaction with other petroleum titleholder operations or exploration activities.	The project will comply with the OPGGS Act 2006 – Section 616 (2) Petroleum safety zones, which includes establishment and maintenance of a petroleum safety zone around the well, offshore structure or equipment which prohibits vessels entering or being present within the specified area without written consent. Accepted procedures will be implemented to meet the requirements of ConocoPhillips' Marine Operations Manual (IOSC/OPS/HBK/0003), which includes details of: • roles, responsibilities and competency requirements • requirements (e.g. storage, transfer) for bulk cargo and bulk liquids (including bunker fuel) operations • general requirements for entering/departure and movement within the designated exclusion or petroleum safety zones • checklist required to be completed for vessels entering the exclusion zones in the development area • safe and sustainable dynamic positioning operations. The Stakeholder Engagement Plan will include consultation with commercial fisheries, shipping, Australian Hydrographic Office (AHO) and other relevant stakeholders operating in the Barossa offshore development area and gas export pipeline to inform them of the proposed project. Ongoing consultation will also be undertaken throughout the life of the project. The FPSO facility will be located away from key commercial shipping channels. The location of the FPSO facility will be communicated to other ships through a Notice to Mariners from the AHO. Subsea infrastructure and pipelines will be clearly marked on Australian nautical charts published by the AHO. Project-vessels operating within the Barossa offshore development area and gas export pipeline corridor will comply with maritime standards such as International Regulations for Preventing Collisions at Sea 1972 (COLREGS), Chapter V of International Convention for the Safety of Life at Sea 1974 (SOLAS), Marine Order 21 (Safety of Navigational and Emergency Procedures) and Marine Order 30 (Prevention of collisions) (as appropriate to vessel class).	The potential impacts and risks associated with the physical presence of the project and vessels are considered broadly acceptable given: • The residual risk is considered low as: ◦ there are no areas of significant importance for commercial fishing or other marine users within the physical footprint of the project infrastructure. • The key management measures are considered effective in managing potential impacts associated with the physical presence of the project and related vessels. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements.	Fixed offshore facilities/ infrastructure and equipment in the Barossa offshore development area will not be located in key areas of importance for commercial fishing and other marine users. No vessel collisions or significant adverse interactions with other marine users.	Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk

Physical presence of offshore facilities/ infrastructure, equipment and project related vessels – interactions with marine fauna	Marine mammals.
	Marine reptiles.
		Injury or mortality of conservation significant fauna.
		Change in marine fauna behaviour and movements.
			The project will be undertaken in accordance with ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as:
			• design planning throughout concept select phase to avoid placement of facilities/ infrastructure within the Barossa offshore development area in areas of regional environmental importance (e.g. shoals/banks, coral reefs, islands, and known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles).
			• use of gas export pipeline selection route surveys to inform route optimisation and reduce environmental impact.
			Screens will be installed on the FPSO facility cooling water intakes to minimise the potential risk of causing injury/ mortality to marine fauna.
			The interaction of the vessels associated with the project with listed cetacean species will be consistent with the EPBC Regulations 2000 - Part 8 Division 8.1 Interacting with cetaceans (except in emergency conditions or when manoeuvring is not possible, such as in the case of pipelay activities), which include:
			• vessels will not knowingly travel > 6 knots within 300 m of a whale
			• vessels will not knowingly approach closer than 100 m to a whale
			• vessels will not knowingly restrict the path of cetaceans.
			Vessel speed restrictions will be implemented within the defined operational area of the gas export pipeline route, except where necessary to preserve the safety of human life at sea. This will be reinforced through training of selected vessel crew to sight and manage interactions with turtles.
			Personnel associated with vessel activities will be subject to project inductions which will address the requirements for vessel operators in relation to interactions with marine fauna.
			No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods.
				The potential impacts and risks associated with the physical presence of the project and vessels are considered broadly acceptable given:
				• The residual risk is considered low as:
				  • the controls outlined limit vessel speeds and therefore marine fauna interactions
				  • there are no regionally significant feeding, breeding or aggregation areas for marine fauna within the Barossa offshore development area
				  • installation activities for the gas export pipeline are of limited duration (6 –12 months)
				  • while the southern end of the gas export pipeline is located within internesting habitat critical to the survival of flatback and olive ridley turtles, installation activities will take into consideration seasonal presence/activity to mitigate potential impacts.
					Fixed offshore facilities/ infrastructure and equipment in the Barossa offshore development area will not be located in regionally important feeding and breeding/nesting biologically important areas for marine mammals or marine reptiles.
					Vessel speeds restricted in defined operational areas within the project area, to reduce the risk of physical interactions between cetaceans/marine reptiles and project vessels.
					Zero incidents of injury/mortality of cetaceans/marine reptiles from collision with project vessels operating within the project area.
					No significant impacts to turtle populations from installation of the gas export pipeline.
						Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Installation schedule of the gas export pipeline take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to as low as reasonably practicable (ALARP) and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/ or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions)	• EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. The key management measures meet the requirements of the EPBC Regulations 2000 – Part 8 Division 1 and the applicable management/recovery plans and conservation advices. • The project aligns with the applicable management/ recovery plans and conservation advices. **Table 6-11** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk

Seabed disturbance	Physical environment – seabed features.
	Marine reptiles.
	Shoals and banks.
	Australian marine parks (AMPs) – Oceanic Shoals.
	Key ecological features (KEF) – shelf break and slope of the Arafura
	Shelf, and the carbonate bank and terrace system of the Van Diemen Rise.
		Direct loss or indirect disturbance of benthic habitat.
		Physical damage and/ or disturbance to unique seafloor KEFs.
		Physical damage and/ or disturbance to benthic habitat within the Oceanic Shoals marine park and to shoals/ banks.
			The project will be undertaken in accordance with the ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as:
			• design planning throughout concept select phase to avoid placement of facilities/ infrastructure within the Barossa offshore development area in areas of regional environmental importance (e.g. shoals, banks, coral reefs, islands, and known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles
			• use of export pipeline selection route surveys to inform route optimisation and reduce environmental impact.
			The location of subsea infrastructure within the Barossa offshore development area will be informed by pre-installation surveys/studies that identify and avoid areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles).
			Pre-lay surveys of the gas export pipeline installation route will be used to identify areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of the Van Diemen Rise KEFs, seabed related conservation values associated with the Oceanic Shoals marine park or nearby shoals and banks (including Goodrich Bank, Marie Shoal and Shepparton Shoal). The outcomes of the pre-lay surveys will be used to inform route optimisation and reduce environmental impacts.
				The residual risk associated with impacts to the Barossa offshore development area is considered low as:
				• Direct disturbance -
				  • the seabed footprint is relatively small at a regional scale with any potential disturbance expected to be very localised.
				  • the Barossa offshore development area does not contain seabed or benthic habitats that are not represented elsewhere.
				• Indirect disturbance -
				  • the placement of infrastructure on the seabed will result in a single brief disturbance resulting in a transient turbid plume.
					No permanent disturbance to benthic habitats beyond the physical footprint of offshore facilities/infrastructure within the Barossa offshore development area and gas export pipeline, as relevant to both direct and indirect sources of disturbance to seabed and associated benthic habitats.
					The FPSO facility and in-field subsea infrastructure will be located in the Barossa offshore development area and will not impact the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (which are > 27 km away) and areas of seabed that are associated with the shelf break and slope of the Arafura Shelf KEF.
					No anchoring or mooring of the FPSO facility and MODU/ vessels on shoals/banks, except in emergency conditions.
						Barossa offshore development area: Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			The MODU/FPSO facility mooring design analysis will include environmental sensitivity and seabed topography analysis to inform selection of mooring locations to avoid areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles). Positioning of the MODU will be undertaken in accordance with the mooring design and analysis and the drilling contractors' rig move procedure, which includes procedures for the deployment and retrieval of anchors using support vessels to minimise seabed impacts.	• The key management measures are considered effective in addressing potential impacts associated with seabed disturbance from the project. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines, ConocoPhillips requirements and the Recovery Plan for Marine Turtles in Australia (**Table 6-14**).	Minimise disturbance beyond the physical footprint by preventing the loss of significant equipment/ cargo overboard from the MODU/ drill ship, FPSO facility or vessels. The gas export pipeline route will be designed to minimise, where practicable, impacts to areas of seabed that are associated with the seafloor features/values of KEFs and shoals/banks. To minimise impact to representative species, assemblages and associated values of the Oceanic Shoals marine park, further studies will be used to inform final pipeline routing so the pipeline will not be installed on those representative species, assemblages and associated values if they have not been found in the marine park outside the pipeline corridor. No significant impacts to turtle or dugong populations from impacts (direct or indirect) associated with installation of the gas export pipeline.	

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Shallow Hazards Study report will be completed prior to drilling of the development wells and include a review of seabed features to inform well location. A Vessel Anchoring Plan will be prepared which will take into consideration anchoring locations and will confirm no anchoring on shoals/banks. Heavy lifting operations between vessels and the MODU/drill ship or FPSO facility will be undertaken using competent personnel appropriate and certified lifting equipment and accessories to minimise the risk of dropped objects. No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP	The residual risk associated with impacts to the gas export pipeline corridor is considered medium as: • Direct disturbance - ◦ the seabed footprint is relatively small at a regional scale with any potential disturbance expected to be very localised, including within the Oceanic Shoals marine park. ◦ the gas export pipeline route will be designed through the subsequent route optimisation process to minimise, where practicable, impacts to areas of the seabed that are associated with the seafloor features/values of the KEFs and shoals/banks. • Indirect disturbance - ◦ there is potential for some of the shoals/banks, a portion of the internesting habitat critical to the survival of flatback and olive ridley turtles, and a small portion of the known significant seagrass sites for dugongs in the vicinity of the pipeline route to be affected by a sediment plume — albeit short-term (in the order of days to several weeks) — should more extensive intervention works (i.e. trenching/dredging) be required during pipelay installation.		Gas export pipeline corridor: Medium

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/ or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP Dredging activities/trenching activities for the gas export pipeline installation (if required) will occur outside the peak flatback (June to September) and olive ridley (April to August) turtle internesting period when within the internesting habitat critical to the survival of these species. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions). Further surveys within the pipeline corridor will be used to supplement existing knowledge from habitat assessments to date, to support an evaluation of the representativeness of species and species assemblages found within the portion of the gas export pipeline corridor that intersects the Oceanic Shoals marine park, with other areas of the marine park.	• impacts from indirect disturbance to seabed and benthic habitats are predicted to be temporary in nature and recoverable within months to years depending on the nature of the benthic habitats present within the proximity of the final alignment. Given the broad area in which internesting behaviour for flatback and olive ridley turtles occurs (i.e. resting in waters less than 30 m deep prior to re-nesting) no impacts to biologically important behaviours are expected as a result of indirect impacts from seabed disturbance. Flatback and olive ridley turtles may be present in offshore waters with water depths of up 55 m during the internesting period, however they are typically freely moving through these areas within the water column rather than requiring benthic habitat for internesting activities.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			If trenching/dredging activities for the gas export pipeline installation are required, i.e. if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, they will occur outside the peak flatback (June to September) and olive ridley (April to August) turtle internesting period. The following process will be used to identify how the pipeline in the section to be trenched/ dredged will be installed to reduce impacts and risks to ALARP and acceptable levels: 1. undertake numerical modelling to predict the extent, intensity and persistence of sediment plumes arising from trenching/dredging activity 2. use the outputs of the numerical modelling to identify key environmental values/sensitivities at risk from trenching/ dredging activities with consideration of background/ baseline conditions and any seasonal presence 3. update of latest knowledge of how aspects arising from trenching/dredging activities can impact the marine environment, including marine turtles and benthic communities 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above with the understanding of the environment (e.g. benthic habitat maps) to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP, i.e. confirm impacts from trenching/dredging will be temporary and localised. Note: if required, additional controls and/ or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. 5. develop a dredge management plan that: • details how trenching/dredging will be undertaken (which will be informed by the information derived from items 1-4 above) • identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels • includes an adaptive management strategy for how trenching/dredging activity will be managed, including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised	• the pipeline corridor has been refined based on geophysical, bathymetric and environmental survey data, to minimise the amount of seabed intervention and stabilisation required. The requirement for, and location of, seabed intervention techniques for the final gas export pipeline route is yet to be defined in detail and the potential environmental impacts and risks associated with the activity will be assessed in further detail in the activity-specific EPs. • The project aligns with the relevant legislative requirements, standards, industry guidelines, ConocoPhillips requirements and the applicable management/recovery plans and conservation advices (e.g. Recovery Plan for Marine Turtles in Australia and the Australian International Union for Conservation of Nature (IUCN) Reserve Management Principles listed in **Section 3.5** relevant to key factors for this aspect).		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			If use of an anchored pipelay vessel is required, i.e.it may only be required if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, the following process will be used to identify how anchored pipelay installation will be undertaken to reduce impacts and risks to ALARP and acceptable levels: 1. use the information and data derived from the pre-lay survey of the gas export pipeline installation route to update understanding of the existing environment along the gas export pipeline route 2. identify any anchor restrictions zones, i.e. areas where anchors cannot be placed, e.g. shoals, banks or coral outcrops 3. define how installation of the pipeline would be undertaken including start-up anchor pattern, operational anchor pattern and lay down (ending) anchor pattern, and predict the number of anchor drops required 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3, with consideration of any seasonal presence, to evaluate the environmental impacts and risks and to verify the impact assessment conclusions are consistent with those presented in this OPP (Note: if required, additional controls and/or mitigation measures will be identified to be implemented to demonstrate consistency with the impact assessment presented in this OPP) 5. develop a pipeline lay anchoring management plan that: • identifies how pipelay installation would be undertaken using an anchored pipelay vessel • identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels • includes an adaptive management strategy for how anchoring activity will be managed including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised			

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk

IMS (biosecurity)	Shoals and banks.
	KEFs – shelf break and slope of the Arafura
	Shelf, and the carbonate bank and terrace system of the Van Diemen Rise.
		Displacement of native marine species.
		Reduction in species biodiversity and decline in ecosystem integrity, particularly of shoals/banks.
			A Quarantine Management Plan will be developed and implemented, which will include as a minimum:
			• compliance with all relevant Australian legislation and current regulatory guidance
			• outline of when an IMS risk assessment is required and the associated inspection, cleaning and certification requirements
			• implementation of management measures commensurate with the level of risk (based on the outcomes of the IMS risk assessment), such as inspections and movement restrictions
			• anti-fouling prevention measures including details on maintenance and inspection of anti- fouling coatings.
			Ballast water exchange operations will comply with the International Maritime Organisation (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 – MARPOL 73/78 (as appropriate to vessel class), Australian Ballast Water Management Requirements (DoAWR 2017) and *Biosecurity Act 2015*, including:
			• all ballast water exchanges conducted > 12 nm from land and in > 200 m water depth
			• vessel Ballast Water Management Plan stipulating that ballast water exchange records will be maintained
			• completion of Department of Agriculture and Water Resources (DoAWR) Ballast Water Management Summary sheet for any ballast water discharge in Australian waters.
			The International Convention on the Control of Harmful Anti-fouling Systems on Ships will be complied with, including vessels (of appropriate class) having a valid International Anti-Fouling Systems (IAFS) Certificate.
			The FPSO facility hull will be subject to an IMS inspection prior to entry into Australian waters.
				The potential impacts and risks associated with the introduction of IMS due to project activities is considered broadly acceptable given:
				• The residual risk is considered low:
				  • given the remote offshore deep water environment and proximity to sensitive shoals and banks to the Barossa offshore development area
				  • the controls outlined are sufficient to manage the risk of impact to values/ sensitivities sensitive to IMS located in discrete areas adjacent to the gas export pipeline corridor (e.g. Goodrich Bank, Marie Shoal and Shepparton Shoal).
				• The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.
				• The project meets the requirements of the environmental legislation, international agreements and conventions and ConocoPhillips requirements (e.g. specifically the *Biosecurity Act 2015* and the NMR Bioregional Plan).
					Prevent the displacement of native marine species as a result of the introduction and establishment of IMS via project-related activities, facilities and vessels.	Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
Underwater noise emissions	Marine mammals. Marine reptiles. Fish. Sharks and rays.	Behavioural disturbance or physiological damage, such as hearing loss, to sensitive marine fauna. Masking or interference with marine fauna communications or echolocation.	The project will be undertaken in accordance with the ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as: • the design of offshore facilities/infrastructure to consider engineering measures to minimise operational noise emissions • placement of project facilities/infrastructure within the Barossa offshore development area to avoid known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles or shoals/banks. Key noise-generating equipment will be maintained in accordance with the manufacturer's specifications, facility planned maintenance system and/or regulatory requirements.	The potential impacts and risks associated with underwater noise emissions from the project are considered broadly acceptable given: • The residual risk is considered low as: ◦ the location of the Barossa offshore development area is in open offshore waters ◦ there are no significant feeding, breeding or aggregation areas for marine fauna, including nearby shoals and banks, within the predicted area of impact (i.e. within approximately 1.4 km during normal operations and 11.4 km during offtake operations which will occur approximately every 80–100 days) for underwater noise from operations activities within the Barossa offshore development area	The outer boundary of the planned operational noise footprint (approximately 12 km from source) within the Barossa offshore development area will not impact the nearest shoals/ banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (located > 27 km away). The use of FPSO facility thrusters will be limited to that required for safe operations and working requirements. No significant adverse impacts to marine fauna populations from VSP operations or pile driving activities. No significant impacts to turtle populations from noise generated during installation of the gas export pipeline.	Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Any vertical seismic profiling (VSP) activities conducted at the development well will comply with 'Standard Management Procedures' set out in EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales: Industry Guidelines (DEWHA 2008d) (or the contemporary requirements at the time of the activity), specifically: • pre start-up visual observations. Visual observations for the presence of whales by a suitably trained crew member will be carried out at least 30 minutes before the commencement of VSP. • start-up and normal operating procedures, including a process for delayed start-up, should whales be sighted. Visual observations by trained crew should be maintained continuously. • night time and low visibility procedures. If required, pile driving activities will align with the Department of Planning, Transport and Infrastructure (2012) 'Underwater Piling Noise Guidelines' which have been adapted from EPBC Act Policy Statement 2.1 (or the contemporary requirements at the time of the activity). The guidelines include: • safety zones – observation and shutdown zones • standard management and mitigation procedures, e.g. pre-start, soft start, normal operation, stand-by and shut-down procedures • consideration of additional management and mitigation measures, e.g. increased safety zones and marine mammal observers. No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods.	• any potential impacts in the Barossa offshore development area are likely to restricted to a small number of individuals that may be traversing through the area • the localised extent of underwater noise from installation activities associated with the gas export pipeline, the relatively short duration of activities (in the order of 6–12 months) and the control measures in place • behavioural responses of commercial fish species are anticipated to be mostly limited to within close proximity of the source (i.e. within hundreds of metres) • the Barossa offshore development area represents a small portion of habitat available to fish populations in the Timor Sea.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/ or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	• The key management controls are considered effective to manage the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines, ConocoPhillips requirements, applicable management/recovery plans and conservation advices and EPBC Act Policy Statement 2.1. **Table 6-25** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk

Atmospheric emissions	Physical environment – air quality.	Localised reduction in air quality.
		
		Contribution to the incremental build-up of GHG in the atmosphere.
			All MODUs/drill ships and vessels (as appropriate to vessel class) will comply with Marine Order 97 (Marine pollution prevention – air pollution), which requires vessels to have a valid International Air Pollution Prevention (IAPP) Certificate (for vessels > 400 tonnage) and use of low sulphur diesel fuel, when possible.
			
			The sulphur content of fuel used by project vessels will comply with Regulation 14 of MARPOL Annex VI (as appropriate to vessel class) in order to control SOx and particulate matter emissions. Fuel gas will be used as the preferred fuel for FPSO processes during operations (instead of diesel or marine gas oil).
			
			Engineering design of the FPSO facility will seek to reduce atmospheric and GHG emissions through energy efficient design.
			
			ConocoPhillips will complete and submit annual National Greenhouse and Energy Reporting (NGER) reports during the operations stage of the project for the Kyoto Protocol listed (or applicable post-Kyoto agreement at the time of operations) greenhouse gas (GHG) emissions on a CO_2 equivalency basis for each facility (as defined in Section 9 of the *National Greenhouse and Energy Reporting Act 2007* and National Greenhouse and Energy Reporting Regulations 2008) by fuel type, and the relevant requirements of the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*.
			
			GHG and National Pollutant Inventory (NPI) reporting records (or contemporary requirements at the time of the activities) will be complied with during the project for facilities where ConocoPhillips has operational control.
			
			A preventative maintenance system will be implemented, which includes regular inspections and maintenance of engines and key emission sources and emissions control equipment in accordance with the vendor specifications.
			
			The requirements of the *Ozone Protection and* Synthetic *Greenhouse Gas Management Act 1989* and Regulations 1995 will be met, specifically in relation to ozone depleting substances.
				The potential impacts and risks associated with atmospheric emissions from the project are considered broadly acceptable given:
				• The residual risk is considered low given:
				  • the location of the project in the open ocean, which is well-removed from nearest residential or sensitive populations of the Tiwi Islands or NT coast
				  • the relatively minor contribution (0.5–0.7%) to the domestic GHG emissions profile.
				• The key management measures are considered effective to manage the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks.
				• The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.
				• The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements (e.g. specifically the *National Greenhouse and Energy Reporting Act 2007*, including the Safeguard Mechanism, the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and Regulations 1995, and MARPOL 73/78 Annex VI, Marine Order 97, *National Greenhouse and Energy Reporting Act 2007* and Regulations 2008).
					Atmospheric emissions associated with the project will meet all regulatory source emission standards.
					
					Engineering design of the FPSO facility will seek to reduce atmospheric and GHG emissions through energy efficient design.
					
					Combustion engines and flaring equipment will be maintained according to vendor specifications to achieve optimal performance.
						Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk

Light emissions	Marine reptiles.
	
	Birds.
		Change in fauna movements and/ or behaviour, such as the attraction or disorientation of individuals.	All vessels in Australian waters adhere to the navigation safety requirements contained within COLREGS, Chapter 5 of SOLAS, the *Navigation Act 2012* and subordinate Marine Order 30 (Prevention of Collisions) (as appropriate to vessel class) with respect to navigation and workplace safety equipment (including lighting).
			
			International Association of Marine Aids Navigation and Lighthouse Authorities (IALA Recommendation O-139 on The Marking of Man-Made Offshore Structures will be followed.
			
			External lighting on offshore facilities/infrastructure will be minimised to that required for navigation, safety and safety of deck operations, except in the case of an emergency.
			
			No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods.
			
			Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels:
			1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs
			2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP
				The potential impacts and risks associated with light emissions from the project are considered broadly acceptable given:
				• The residual risk is considered low as:
				  • the predicted area of influence from lighting within the Barossa offshore development area does not contain any significant feeding, breeding or aggregation areas for marine fauna, or emergent shorelines
				  • minimal light (levels comparable to between a quarter and full moon) influencing the surface waters above the nearest shoals/banks from the Barossa offshore development area (located 27 km–35 km away) is not anticipated to significantly impact marine fauna at these locations
				  • light impacts to marine fauna within the vicinity of the gas export pipeline (in particular turtles and the crested tern) are anticipated to be minor given the distance (> 6 km) from emergent shorelines on the Tiwi Islands where turtle hatchlings and crested tern nesting areas are located
				  • no permanent light sources are required along the gas export pipeline.
					Light spill from the MODUs/drill ships, FPSO facility and project vessels will be limited to that required for safe operations and working requirements.
					
					No significant impacts to turtle populations from installation of the gas export pipeline.
						Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the impact assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	• The key management measures are considered effective to manage the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements and applicable recovery plans and conservation advices. **Table 6-30** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
Planned discharges	Physical environment – water quality and sediment quality. Shoals and banks. KEFs – shelf break and slope of the Arafura Shelf.	Localised and temporary reduction in water quality associated with increased turbidity, water temperature or salinity leading to impacts to marine fauna. Localised displacement, smothering (mainly associated with discharge of drill fluids and cuttings) or toxicity of benthic habitats/ communities that are regionally widespread.	*General* All planned discharges from vessels will comply with relevant MARPOL 73/78 and Australian Marine Order requirements (as appropriate for vessel classification). All planned operational discharges will be managed in accordance with a project Waste Management Plan (and as detailed in activity-specific EPs). Pre-installation surveys will be undertaken to confirm the FPSO facility is not located in the vicinity of areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles) and nearby shoals and banks (including Lynedoch Bank, Tassie Shoal and Evans Shoal, all > 27 km away). A maintenance program will be developed and implemented for the FPSO facility which includes inspection and maintenance of treatment systems to confirm discharge limits are met. All chemicals (hazardous and non-hazardous) used on the FPSO facility will undergo a HSE assessment and be approved prior to use. The HSE assessment required by the procedure aims to identify and control health and environmental risks during transport, use and storage of the chemicals. The procedure includes: • definition of key roles and responsibilities • the process for approvals and registration of chemicals • key requirements for safe transport, handling and storage.	The potential impacts and risks associated with planned discharges from the project are considered broadly acceptable given: • The residual risk of impact from planned discharge of drill cuttings and WBM fluids in the Barossa offshore development area is considered low given the relatively short duration of development drilling, the fact that discharge of sediment is contained within the Barossa offshore development area where no significant benthic communities have been identified, and no contact is predicted with the closest shoals/ banks. Impacts beyond temporary minor effects to water quality (e.g. turbidity increase) and localised burial, smothering and displacement of commonly represented benthic habitats and communities are not anticipated.	All planned operational discharges from the FPSO facility: • will not exceed the natural variation of existing baseline water quality conditions for temperature and hydrocarbons, and mercury or chlorine concentrations outside the Barossa offshore development area, and • will not impact areas of seabed that are associated with the seafloor features/ values of KEFs or the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (located > 27 km away from the Barossa offshore development area, which is beyond the outer boundary of planned operational discharges), and • meet relevant ANZECC/ ARMCANZ and/or natural variation in ambient baseline conditions (where determined to be more relevant to the site-specific context to derive reference values) beyond the predicted mixing zone(s). Dewatering discharges will not extend beyond the Barossa offshore development area and will not impact areas of seabed that are associated with the seafloor features/values of KEFs or the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal.	Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			ConocoPhillips will confirm that the selection of chemical products within the planned discharge streams that are discharged to the marine environment are subject to a chemical assessment process. Products that meet at least one of the following environmental criteria are considered suitable by ConocoPhillips for use and controlled discharge to the marine environment is permitted: • rated as Gold or Silver under Offshore Chemical Notification Scheme (OCNS) Chemical Hazard and Risk Management (CHARM) model • if not rated under the CHARM model, have an OCNS group rating of D or E (i.e. are considered inherently biodegradable and non-bioaccumulative). The use of products that do not meet these criteria will only be considered following assessment and approval through a chemical assessment process, as outlined above. The assessment will also be informed by an environmental risk assessment which will help ensure that any potential environmental impacts resulting from chemical use and discharge are minimised. *Drill fluids* No planned discharge of whole synthetic based mud (SBM) will occur overboard. When using SBM, the solids control equipment will reduce the residual base fluid on cuttings content prior to discharge overboard. Residual base fluid on cuttings will be less than 10% by weight (w/w), averaged over all well sections drilled with SBM.	• The residual risk of impact from planned discharge of PW, cooling water, wastewater and brine is considered low given that the discharge extent is localised and strong currents and mixing within the open ocean environment are predicted to cause rapid dilution, reaching levels below those which may cause harm to marine species within the Barossa offshore development area. Therefore, contact with shoals/banks, reefs and islands, AMPs or KEFs was predicted to be highly unlikely. The potential for impact associated with the bioaccumulation of PW, cooling water or wastewater constituents in benthic sediments is considered low and limited to a potential localised effect on a limited number of benthic fauna species immediately surrounding the FPSO facility. • The residual risk of impact from planned dewatering discharge is considered low given the expected area of influence associated with the discharge is localised within the Barossa offshore development area, exposure is of a short term duration, and the nature of benthic habitats and associated species within the vicinity of the FPSO facility are represented elsewhere.	All discharges of SBM residual base fluid on cuttings from drilling activities will be below 10% w/w oil-on-cuttings averaged over all well sections drilled with SBM. Reduce impacts to the marine environment from planned discharges through the application of a chemical selection process, which includes an environment risk assessment.	

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Produced water (PW) and cooling water An environmental monitoring program (**Section 7.2.3**) and adaptive management framework (**Section 7.3**) will be applied to manage PW and cooling water discharges. Mercury levels in PW discharge will be subject to monitoring during operations to confirm that concentrations remain within acceptable discharge limits. PW and cooling water will be discharged below the sea surface to maximise dispersion. Development of a predicted mixing zone(s) for PW and cooling water within the Operations EP, as informed by modelling and validation studies. During operations, verification monitoring and reporting of temperature and chlorine concentrations of the cooling water discharge stream and hydrocarbon concentrations of the PW discharge stream will be undertaken prior to discharge. Residual chlorine levels in the cooling water discharges will comply with a target of concentration of less than or equal to 3 ppm at the point of discharge to maintain safe operations. The temperature of the cooling water discharge plume from the FPSO will return to within 3 ^{o}C of the ambient temperature within 100 m of the discharge point. PW discharges will have a hydrocarbon content that is no greater than an average of 30 mg/L over any 24-hour period. The oil-in-water (OIW) concentration of PW will be continuously monitored by an installed OIW analyser which will be fitted with an alarm that activates if OIW concentration is > 30 mg/L. Baseline, periodic and 'for cause' (e.g. exceedance of contaminants) toxicity testing of PW discharges will be undertaken against the recognised ecotoxicity assessment methodology defined in ANZECC/ARMCANZ (2000).	• The residual risk of impact from planned hydrotest discharge is considered low given the expected area of influence associated with the discharge is localised, exposure is of a short term duration and there is no predicted contact with the seabed. • The key management measures are considered effective at managing the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements (e.g. OPGGS Act 2006, MARPOL 73/78 and Marine Orders, ConocoPhillips Chemical Management Procedure, North Marine Bioregion Plan). • The project aligns with applicable management/ recovery plans and conservation advices. **Table 6-38** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5**. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Dewatering of flooding fluid The location of the dewatering discharge will be selected to minimise impact on areas of regional environmental importance (e.g. shoals, banks, coral reefs, islands, etc.) to the extent practicable. Flooding fluid chemicals (e.g. biocide, oxygen scavengers and dye) will be selected for environmental performance (i.e. low toxicity chemicals), whilst maintaining technical performance requirements, and follow the chemical assessment process (as detailed above). The dewatering of flooding fluid will be detailed in the relevant activity-specific EPs developed during the detailed engineering and design studies for the project. The EPs will detail dewatering requirements, including definition of discharge characteristics (i.e. chemical additives and concentrations), discharge location and volumes, methodology and species thresholds. *MEG stream* The FPSO facility will have facilities that will regenerate and reclaim MEG for re-use or onshore disposal, if continuous MEG injection is used for flow assurance. *Wastewater and other planned discharges* Oily bilge water from machinery space drainage is treated to a maximum concentration of 15 ppm OIW prior to discharge from vessels, as specified in MARPOL 73/78 (Annex I). Offshore discharge of sewage from vessels will be in accordance with MARPOL 73/78 (Annex IV) and Marine Order 96. Food wastes from vessels will be macerated to < 25 mm diameter prior to discharge, in accordance with MARPOL 73/78 (Annex V) and Marine Order 95. Detailed performance criteria for planned discharges will be defined in the activity-specific EPs.			

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk

Waste management	Physical environment – water quality.
	Marine mammals.
	Marine reptiles.
		Temporary and localised reduction in water quality, i.e. pollution or contamination of the marine environment.
		Interaction of marine fauna with solid wastes, such as plastic packaging, which may result in physical injury or mortality (through ingestion or entanglement) of the individual.
			All wastes generated offshore will be managed in accordance with relevant legal requirements, including MARPOL 73/78 and Australian Marine Order requirements (as appropriate for vessel classification).
			A project Waste Management Plan will be developed and implemented, and will include details of:
			• the types of waste that will be generated by the project and will require containment, transport to, and disposal at, a licensed facility onshore
			• management protocols for the handling, segregation and responsible disposal of wastes. For example, non-hazardous and hazardous solid and liquid wastes will be transported safely to shore and disposed onshore at licensed treatment and disposal facilities.
			• measurable performance criteria
			• competency and training
			• audits, reporting and review, including compliance checks via waste manifests.
			Hydrocarbon and chemical storage and handling procedures will be implemented, including:
			• secure storage of bulk hydrocarbons and chemicals in areas with secondary containment
			• storage of hydrocarbon and chemical residues in appropriate containers
			• stocks of Shipboard Oil Pollution Emergency Plan (SOPEP) spill response kits readily available to respond to deck spills of hazardous liquids and personnel trained to use them
			• planned maintenance system including maintenance of key equipment used to store and handle hydrocarbons/ chemicals (e.g. bulk transfer hoses, bunding)
			• Material safety data sheet (MSDS) available on board for all hazardous substances.
				The potential impacts and risks associated with inappropriate waste management are considered broadly acceptable given:
				• The residual risk of impact is considered low as:
				  • the likelihood of occurrence and the nature of the existing environment in the immediate vicinity of project activities (e.g. no areas of significant feeding, breeding or aggregation for marine fauna)
				  • any potential impacts to local water quality are likely to be for a short duration only.
				  • good housekeeping practices will be implemented on all project vessels, therefore reducing the risk of accidental overboard discharge of wastes on the receiving environment.
					Zero unplanned discharge of hazardous and non-hazardous wastes into the marine environment as a result of project activities.
					Hazardous waste will be transported onshore for treatment and/or disposal at licenced treatment and disposal facilities.
						Low

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Non-hazardous and hazardous wastes will be managed, handled and stored in accordance with their MSDS, and tracked from source to their final destination at an appropriately licensed waste facility. Heavy lifting operations between vessels and the MODU/ drill ship or FPSO facility will be undertaken using competent personnel and certified lifting equipment and accessories to minimise the risk of dropped objects.	• The key management measures are considered effective at managing the risk and will be enforced through auditing and reviews. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements (e.g. MARPOL and Marine Orders, relevant recovery plans). • The project aligns with applicable management/ recovery plans and conservation advices. **Table 6-41** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5**.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
Unplanned discharges	Physical environment – water quality and sediment quality. Shoals and banks. Tiwi Islands. Other offshore reefs and islands and NT/ WA mainland coastline. Marine mammals. Marine reptiles. Birds. Fish. Sharks and rays. Commercial fishing. Recreational and traditional fishing (Tiwi Islands)	Reduction in water quality. Direct toxic or physiological effects on marine biota, including corals, mammals, reptiles, birds, fish and sharks/ rays. Hydrocarbon/ chemical contact with shoals/ banks, reefs and islands at concentrations that result in adverse impacts. Alteration of biological communities as a result of the effects on key marine biota. Socio-economic impacts on commercial fishing, traditional fishing (Tiwi Islands) and tourism.	*General* The OPGGS Act 2006 – Section 616 (2) Petroleum safety zones will be complied with, including establishment and maintenance of a petroleum safety zone around the well, offshore structure or equipment which prohibits vessels entering or being present within the specified area without written consent. Bunkering procedures will be implemented, which include: • use of bulk hoses that have dry break couplings, weak link break-away connections, vacuum breakers and floats • correct valve line-up • defined roles and responsibilities – bunkering to be undertaken by trained staff • visual inspection of hose prior to bunkering to confirm they are in good condition • testing emergency shutdown mechanism on the transfer pumps • assessment of weather/sea state • maintenance of radio contact with vessel during bunkering operations.	The potential impacts and risks associated with unplanned discharges from the project are considered broadly acceptable given: • The residual risk is considered acceptable, as the proposed key management controls are considered good industry practice, take into consideration the key values and sensitivities of the marine environment within the area of influence from a potential spill and manage any potential additional impacts and risks which may be introduced as a result of the implementation of the mitigation measures (i.e. Oil Pollution Emergency Plans (OPEPs) and Operational and Scientific Monitoring Plan (OSMP)). • There is the potential for minor impacts to benthic communities located at Shepparton Shoal adjacent to the tie in location in the event wet buckling occurs in the immediate vicinity. However, the likelihood of wet buckling occurring within the immediate vicinity of the tie-in location is unlikely and the exposure timeframe associated with a wet buckling event at this location is relatively short duration. Further, given the ecological connectivity predicted amongst shoals in the region (Heyward et al. 2017) there are unlikely to be any unique features of significance at these locations, and as such impacts from wet buckling are expected to be minor.	Zero unplanned discharge of hydrocarbons or chemicals to the marine environment as a result of project activities. An activity-specific OPEP that demonstrates adequate arrangements for responding to and monitoring oil pollution in the event of a major unplanned release will be accepted by NOPSEMA prior to commencing the activity. An OSMP will be implemented in the event of a major unplanned release. The OSMP will include a number of operational monitoring plans and scientific monitoring plans to guide the spill response, and assess potential environmental impacts.	Medium

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Hydrocarbon and chemical storage and handling procedures appropriate to nature and scale of potential risk of accidental release will be implemented, which will include: • bulk hydrocarbons and chemicals stored in designated areas, with secondary containment • stocks of SOPEP spill response kits readily available onboard and personnel trained to use them • MSDS available on board for all hazardous substances. An Inspection Monitoring and Maintenance Program will be developed for the gas export pipeline to assess structural integrity and for any potential leaks. A simultaneous operations (SIMOPS) procedure will be implemented to control and manage any concurrent SIMOPS activities. *Long-term well blowout prevention* All well design and control activities will be undertaken in accordance with a NOPSEMA approved Well Operations Management Plan (WOMP) and as detailed in activity-specific EPs. All drilling activities will be undertaken in accordance with accepted procedures that meet the requirements of the: • ConocoPhillips Well Construction and Intervention standard, which outlines minimum requirements (including testing and maintenance) for well control equipment (e.g. blowout preventer, casings/tubings and drilling mud systems) • ConocoPhillips Well Design and Delivery Process documentation including Well Engineering Basis of Design, Critical Well Review and Shallow Hazard Study • ConocoPhillips Wells Management System, which includes the requirement for a minimum of two barriers that are tested and maintained during all well operations.	• The key management measures align with relevant legislative requirements, standards, industry guidelines and ConocoPhillips HSEMS, HSE Policy, SD Policy, and Company standards and systems. • The comprehensive preventative management and response arrangements that ConocoPhillips has in place. • The approach applied to the project is consistent with the principles of ESD, as discussed below: • Of particular relevance to this aspect: • Physical environment (water quality and sediment quality) – the impact evaluation identifies the low probability of unplanned discharges and the potential evaluation of consequences, as relevant to the existing environment relevant to this proposal.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			A MODU/drill ship Safety Case Revision will be developed and implemented, which describes the ConocoPhillips and MODU Operators agreed well control interface. *Vessels/facilities* The FPSO facility will be designed so that the hull shall be double-walled or double sided and compartmentalised condensate storage tanks. Vessel specific controls will align with MARPOL 73/78 and Australian Marine Orders (as appropriate for vessel classification), which includes managing spills aboard, emergency drills and waste management requirements. Vessel movements will comply with maritime standards such as COLREGS and Chapter V of SOLAS. Offtake vessels will be piloted during berthing and offloading operations. Visual monitoring of the offloading manifold and hose will be maintained during offtake operations to allow for rapid emergency shut down. All marine contracted vessels will undergo the ConocoPhillips Global Marine vetting process, which involves inspection, audit and a review assessment for acceptability for use, prior to working on the project. Vessel selection criteria will make considerations for designs and operations which reduce the likelihood of hydrocarbon spills to the marine environment as a result of a vessel collision. All vessels involved in the project will have a valid SOPEP or SMPEP (as appropriate for vessel classification). *Response measures* (refer to **Section 7.2.2** for further discussion of emergency preparedness and response)	• Benthic habitats (including shoals and banks, Tiwi Islands, other offshore reefs and islands and mainland coastline) – the key management controls that will be implemented take into consideration the key values and sensitivities of the marine environment within the area of influence from a potential spill and are considered to manage potential impacts and risks to an acceptable level. An activity-specific OPEP that demonstrates adequate arrangements for responding to and monitoring oil pollution, in the event of a major unplanned release, will be accepted by NOPSEMA prior to commencing the activity. • Marine fauna (including marine mammals, marine reptiles, birds and fish) - the project aligns with applicable management/ recovery plans and conservation advices. **Table 6-47** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect.		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
			Spill response in the event of a hydrocarbon or chemical spill will be implemented safely and be commensurate with the type, nature, scale and risks of the spill to key values and sensitivities, as defined in activity-specific OPEPs. A Crisis Management Plan will be implemented in the event of a spill, which includes: • emergency response planning • emergency management structure • incident notification • emergency response responsibilities and support providers. An OSMP will be initiated and implemented as appropriate to the nature and scale of the spill and the existing environment, as informed by a net environmental benefit assessment. ConocoPhillips will have additional contingency plans in place in the event of a well blowout, including side track relief well drilling, well capping and existing contracts with spill response agencies to facilitate efficient implementation of appropriate spill response measures.	Consistent with the above conclusion, the application of key controls to be applied at all stages of the proposal, will be implemented to minimise risk. No population level impacts are expected as a result of unplanned discharges, although individuals may be affected in the area of influence that is dependent on the nature and scale of a potential release, and the appropriate spill response framework. ConocoPhillips has been operating in Australia and the Joint Petroleum Development Area since the mid- 1990s. The Company is successfully operating the Bayu-Undan gas condensate field and has successfully completed a number of drilling campaigns in the Timor Sea and Browse Basin through its Australian business units without major incident. Operations at Bayu-Undan have included the safe transfer of hydrocarbons to tankers offshore and more than 600 shipments to overseas markets. Titles for oil and gas exploration are released based on commitments to explore with the aim of uncovering and developing resources. To satisfy offshore permit retention lease requirements, ConocoPhillips has an obligation to undertake		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
				exploration in the Barossa offshore development area and develop commercially viable hydrocarbon reserves in a safe and responsible manner. The conservation of biological diversity and overall ecosystem integrity has been considered in the environmental risk assessment, and has been informed by a detailed understanding of the existing marine environment within the Barossa offshore development area and surrounds (**Section 5**). Specifically, ConocoPhillips has undertaken a comprehensive and robust environmental baseline studies program to characterise the existing marine environment (**Section 5.2**). Where limited scientific information exists within the area of influence, ConocoPhillips conservatively assumes that the marine environment is of high inherent value and, therefore, implements all practicable/feasible measures to prevent potential impacts. ConocoPhillips corporate HSE Policy and SD Position outline expectations and principles of operations that require consideration of sustainability, the environment and communities within areas in which the Company operates (**Figure 2-2** and **Figure 2-3**). ConocoPhillips recognise there is an inherent risk of unplanned discharges in undertaking the project. However, through the implementation of established and comprehensive policies, standards, procedures and processes, in conjunction with relevant legislation,		

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome	Residual risk
				ConocoPhillips considers that despite this risk, the extremely low likelihood of a significant spill event (e.g. vessel collision leading to a significant loss of hydrocarbons or long-term well blowout) being realised is manageable. ConocoPhillips also considers the overall level of risk is broadly acceptable as the likelihood of such an event occurring during the project is similar to the Bayu-Undan operations, which has not had a significant spill event since installation activities commenced in 2004.		
Decommissioning	Physical environment (seabed features and, water quality and underwater noise).	Physical damage and/ or disturbance to marine substrates and, benthic habitats and marine biota. Temporary and localised reduction in water quality.	Prior to the end of operating life, a decommissioning options study will be undertaken to inform the development of a Decommissioning EP that will be submitted to NOPSEMA. The Decommissioning EP will consider a range of decommissioning options (including those outlined in **Section 4.3.4**). The decommissioning options study will consider the merits of each option in the context of health, safety and environmental protection, technological feasibility, local capacity, regulatory compliance, public participation and economic stewardship within a broader ALARP framework to inform selection of the preferred decommissioning strategy. The ALARP framework will seek to minimise disturbance to marine habitats and will include justification for removing or leaving infrastructure on the seabed. The Decommissioning EP will be implemented for the duration of the decommissioning activities.	Direct and indirect impacts arising from decommissioning activities at the end of the field life are expected to be broadly comparable with that generated from installation activities which, for each key aspect (in particular seabed disturbance and noise), have been concluded to be acceptable. A Decommissioning EP will identify all risks and impacts to the environment and consider a net environmental benefit and ALARP assessment of the proposed decommissioning activities. Approval required under the Offshore Petroleum Greenhouse Gas Storage Act (2006) (or contemporary requirements at the time) will take into account that the activity is undertaken in a manner that protects the offshore workforce and the environment, and is consistent with the principles of ecologically sustainable development.	Decommissioning will not commence until a Decommissioning EP is accepted (by the regulator with jurisdiction for decommissioning at the time), to be informed by the outcomes of a decommissioning options study that considers ALARP and acceptability. The accepted Decommissioning EP will be consistent with any published Commonwealth Government policy or legislation prevailing at the time, as relevant to the environmental merit of removing or leaving infrastructure on the seabed upon abandonment and decommissioning of project facilities.	Low

Cumulative impacts

The cumulative impact assessment presented in the OPP takes into consideration potential project impacts and impacts of other activities, including existing activities and potential future oil and gas developments.

A number of activities currently exist within or in close proximity to the project, specifically commercial fishing (Commonwealth and NT-managed fisheries) and shipping. These activities were not included as a part of the cumulative assessment as they are considered part of the existing baseline socio-economic environment assessed in the OPP. While a number of oil and gas companies hold petroleum permits in the vicinity of the project, there are no established operations within, or in the immediate surrounds.

For the purposes of the OPP, the cumulative impact assessment takes into consideration offshore oil and gas projects that will be of comparable spatial and temporal scales, namely the INPEX Masela Abadi FLNG project (approximately 10 km from the project area) and Melbana Energy Tassie Shoal methanol project (approximately 37 km from the project area).

The project will not result in any material cumulative impacts to the marine environment at a local scale as there is no significant overlap with other proposed offshore oil and gas projects. No cumulative impacts to MNES, particularly EPBC listed species, are expected. Regional cumulative impacts may occur in terms of incremental increases in vessel movements and GHG emissions. However, these have been assessed as minor and do not change the residual risk rankings for any of the potential impacts assessed in the OPP.

Environmental management and monitoring framework

Alignment with the EPOs will be achieved through the application of a comprehensive environmental management and monitoring framework and implementation strategy, which includes consideration of relevant environment legislation and the ConocoPhillips Health, Safety and Environment Management System procedures and standards. An adaptive management framework will be applied as the project progresses through its life-cycle. The framework will provide overarching governance for the measurement and monitoring of key environmental parameters to enable appropriate responses to incidents, and confirm that project-related effects on environmental values and sensitivities are managed to an acceptable level.

The OPP presents an outline of the environmental monitoring framework for the project with the objective:

- to monitor discharges and emissions to ensure compliance with relevant legislation, standards and ConocoPhillips' environmental objectives for the project
- to determine whether environmental changes are attributable to the project activities, other activities or as a result of natural variation
- to enable reliable data to inform an appropriate corrective course of action if required, and
- to provide a basis for continuous review and improvement to the management and monitoring arrangements over the project life-cycle.

The framework monitoring program comprises:

- planned marine discharges monitoring – from the FPSO facility, monitoring of the marine environment that may be influenced, whole-of-effluent testing of the PW discharge stream and ongoing monitoring of in-line PW and cooling water and verification
- atmospheric emissions monitoring for GHG emissions, criteria pollutant emissions and flare monitoring and optimisation
- assessment of benthic habitats in the immediate vicinity of the selected gas export pipeline
- decommissioning monitoring.

Project acceptability

ConocoPhillips takes into account a range of considerations when evaluating the acceptability of environmental impacts and risks associated with its projects. The approach adopted in this OPP to defining the threshold of acceptability is based on and is aligned with NOPSEMA guidance.

Overall, ConocoPhillips considers the project to be acceptable, as informed by a risk-based assessment, taking into account that:

- the remote project location of the Barossa offshore development area, which is predominantly located in deep, open offshore waters, means no facilities will be placed near any areas of regional environmental importance such as shoals, banks, coral reefs, or biologically important areas or habitats critical to the survival for marine fauna
- planned operations have a relatively limited extent, with the impacts and risks considered low

- the risks of unplanned releases is medium, however the likelihood is remote given comprehensive management controls will be implemented
- the implementation of key management controls and clear definition of appropriate and measurable EPOs that will assist in managing all environmental aspects of the project
- the project will be undertaken in accordance with relevant legislation, standards and industry guidelines, consistent with the principles of ESD and ConocoPhillips expectations for responsible environmental management.

Consultation

ConocoPhillips understands the importance of thorough, meaningful and ongoing consultation with stakeholders as part of its regulatory commitments and social licence to operate.

ConocoPhillips is committed to thorough meaningful and ongoing consultation with stakeholders throughout the life-cycle of the project. For this OPP, ConocoPhillips' understanding of stakeholder issues and concerns has been informed through prior consultation around specific activities and development concepts. Consultation supporting the project commenced in 2004 and has involved engagement with a broad range of stakeholders including community members, governments, spill response agencies, commercial fishing associations and licence holders, educational and scientific organisations, other oil and gas industry operators, contractors and non-government organisations. Engagement in recent years has included the plans to develop the project as a future backfill gas supply for the DLNG facility.

Based on its history of proactive consultation, ConocoPhillips believes stakeholders support development of the Barossa offshore development area and the continued economic benefit it will deliver to Australia, in particular to the NT, and understand that a new gas resource will be required once the Bayu-Undan Field is exhausted. This understanding has been reinforced as a result of the formal public comment period.

The public was invited to submit their comments on the project to NOPSEMA for consideration during an eight week public comment period from 13 July to 6 September 2017. ConocoPhillips publicly advertised that the Barossa OPP was available for public comment period and communicated directly to its stakeholders, including on how to make a submission. This information was also available on the NOPSEMA and ConocoPhillips websites.

Comments received from stakeholders during the public comment period have been taken into consideration, in this revised version of the OPP submitted to NOPSEMA for Stage 2 assessment of acceptability. A summary of all comments received and an assessment of the merits of all items raised, including ConocoPhillips' response (Appendix R). A formal response has also been provided to all written comments received during the public comment period.

Following the original submission of the OPP to NOPSEMA for Stage 2 assessment of acceptability, additional correspondence with stakeholders has been undertaken as follows.

1. Parks Australia provided further advice in relation to the comments made in the Director of National Parks' original submission and, after discussion with Parks Australia, ConocoPhillips has revised its assessment of merit and response to the comments to that presented in **Appendix R**.

2. After the OPP was submitted for assessment, the Department of the Environment and Energy updated the National Conservation Values Atlas to include the feature 'Marine Turtles – Habitat Critical (Draft)'. As a result, ConocoPhillips re-evaluated its assessment of merit and response to some of the comments received during the public comment period and has revised the OPP, including **Appendix R**, based on this re-evaluation.

Where revisions were made to the original assessment of merit and response, the revised information, as presented in **Appendix R**, was provided directly to the stakeholder that made the original comment to keep them updated with how their comments have been taken into consideration and addressed in the OPP.

Upon acceptance of the Barossa OPP by NOPSEMA, ConocoPhillips will commence preparation of Environment Plans (EPs) for project activities. The preparation and assessment of specific EPs for each activity in the project will involve detailed consultation with relevant stakeholders.

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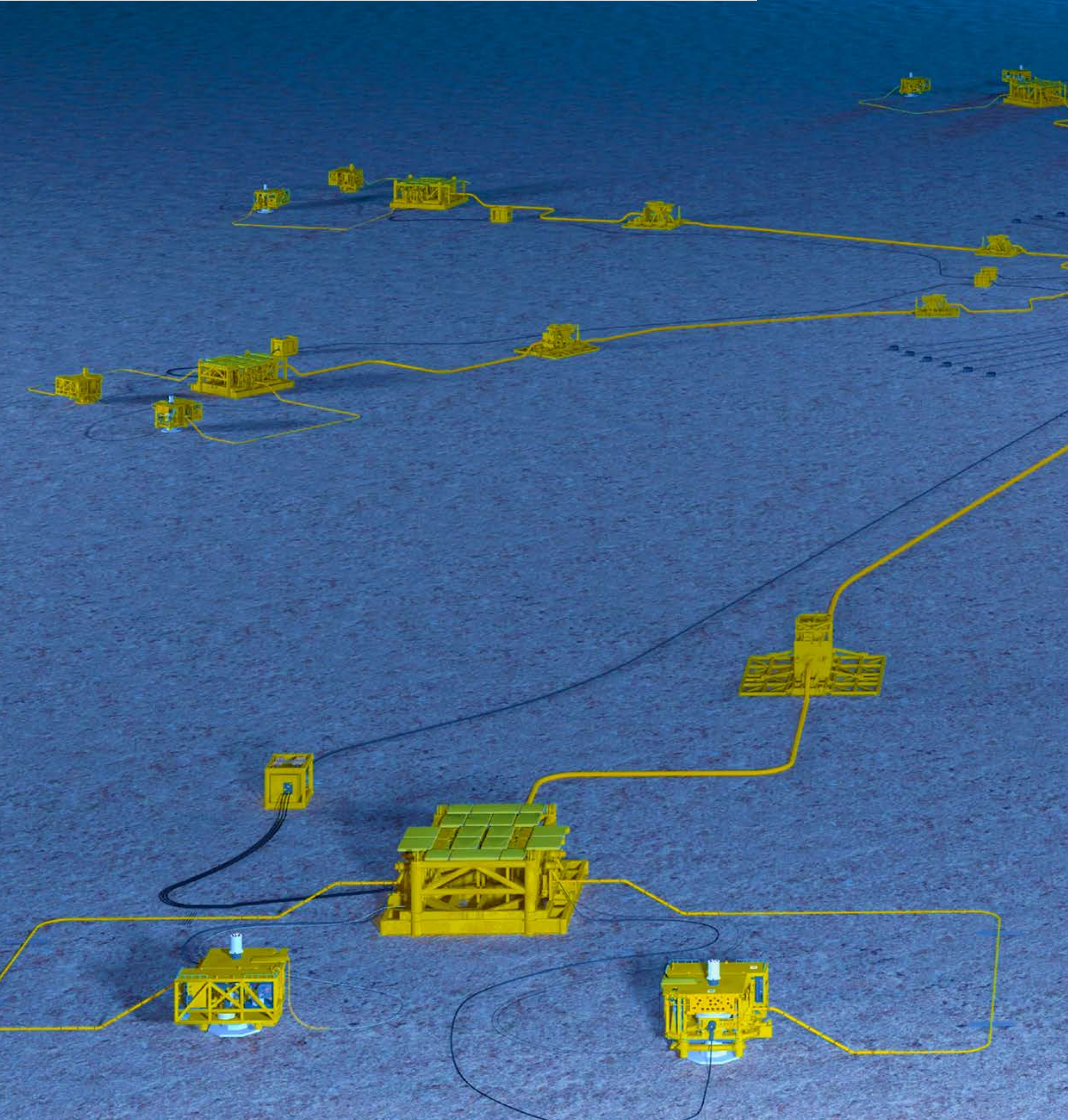
1 Introduction



Section 1 summary

Purpose:

This section provides an overview of the proposed development, a summary of the content and structure of the document, and a description of the proponent (ConocoPhillips on behalf of the current co-venturers SK E & S Australia Pty Ltd and Santos Offshore Pty Ltd).

Section at a glance:

Proposed development: The Barossa Area Development is a gas and light condensate project that proposes to provide a new source of dry gas to the existing Darwin LNG (DLNG) facility. The project will be located approximately 300 km north of Darwin, 227 km offshore (nearest point to mainland) and 100 km north of the Tiwi Islands.

The development concept includes a Floating Production Storage and Offloading (FPSO) facility, subsea production system, supporting in-field subsea infrastructure and a gas export pipeline, all located in Commonwealth waters. The FPSO facility will separate the natural gas and condensate extracted from the field with the dry gas proposed to be transported via a gas export pipeline for onshore processing. The condensate will be exported directly from the FPSO facility to offtake tankers.

The new pipeline that will transport the dry gas from the Barossa offshore development area will be approximately 260 km–290 km long and while appropriate commercial arrangements are yet to be put in place, it is proposed to connect to the existing Bayu-Undan to Darwin pipeline in Commonwealth waters.

The exact route of the new pipeline is not final and subject to further studies.

The project will continue to help meet current and future global demand for natural gas and contribute income and employment opportunities for Australia.

Summary of content and structure of the document: The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) has prepared a guidance note outlining the Offshore Project Proposal (OPP) content requirements and the information presented in **Section 1** provides an overview of the required information. Subsequent sections will present further detail to address specific content requirements. It is recommended to consider this guidance note in conjunction with this OPP, as it provides context for the structure and content. The guidance note is available on the NOPSEMA website, https://www.nopsema.gov.au/assets/Guidance-notes/A473026.pdf.

The OPP is prepared during a project's early design phase and considers all potential environmental impacts and risks over the project's life-cycle. The OPP details the risk assessment undertaken and demonstrates that the project can be undertaken in an environmentally acceptable manner. The OPP process will deliver environmental outcomes equivalent to the assessment process under the *Environment Protection and Biodiversity Conservation Act 1999*.

NOPSEMA first assesses the OPP to make sure it has the required content for public release and comment. It must be easily navigable and comprehensible to the public, which is why summaries have been prepared for each section. The OPP was then released for an eight-week public comment period and was updated and re-submitted to NOPSEMA for assessment of the environmental acceptability of the project. The definition of 'acceptable' is explained in more detail in **Section 6** of this document. Confirmation, through the OPP process, that the project is considered acceptable will give ConocoPhillips and its partners the confidence to continue their financial investment and planning.

Acceptance of an OPP by NOPSEMA does not mean a project can proceed. Acceptance provides approval for the submission of separate Environment Plans (EPs) for project activities to NOPSEMA for assessment. EPs include further detail of how the impacts and risks for each activity will be managed. Only after an EP has been accepted by NOPSEMA, can that activity commence.

Description of proponent: ConocoPhillips, the proponent for this OPP on behalf of the current and future co-venturers, is the world's largest independent exploration and production company and has been conducting activities in Australia and the Joint Petroleum Development Area (JPDA) in the Timor Sea between Australia and Timor-Leste since the mid-1990s. ConocoPhillips operates (on behalf of current and future co-venturers) the Bayu-Undan gas condensate field in the JPDA, the DLNG facility in the Northern Territory, and a 502 km gas export pipeline that links the two facilities.

1 Introduction

1.1 Overview

ConocoPhillips Australia Exploration Proprietary (Pty) Limited (Ltd.) (ConocoPhillips), as proponent on behalf of the current and future co-venturers, is proposing to develop hydrocarbon resources in the Timor Sea into high quality products in a safe, reliable and environmentally responsible manner.

The Barossa Area Development (herein referred to as the "project") is located in Australian Commonwealth waters within the Bonaparte Basin, approximately 300 kilometres (km) north of Darwin, Northern Territory (NT) (**Figure 1-1**).

This Offshore Project Proposal (OPP) includes in-field infrastructure in the Barossa Field in petroleum retention lease NT/RL5, and a subsea gas export pipeline. While appropriate commercial arrangements are yet to be put in place, it is proposed to connect the new subsea gas export pipeline to the existing Bayu-Undan to Darwin gas export pipeline which feeds the onshore Darwin Liquefied Natural Gas (LNG) facility. This would allow transport of dry gas from the Barossa Field for liquefaction and export from Darwin. Potential future staged development in the smaller Caldita Field to the south in retention lease NT/RL6 has also been accommodated in this OPP.

Throughout this document, the terms 'Barossa offshore development area' and 'gas export pipeline' (collectively referred to as 'the project area') are used to describe the geographic extent of this project (**Figure 1-1**). Refer to **Section 4.2.1.1** for further discussion on the definition of the project area.

The project will:

- meet current and future global demand for natural gas
- develop large discovered resources, thereby contributing substantial income to the region by way of royalties and taxes
- provide employment opportunities in the region
- allow the continued utilisation and operation of the existing Darwin LNG (DLNG) facility following the decline of the Bayu-Undan Field currently supplying dry gas to DLNG.

ConocoPhillips believes the project can be developed and operated in an environmentally sustainable manner and that environmental impacts and risks can be managed to an acceptable level.

Table 1-1 provides a summary of key project information.

Table 1-1: Key project information

Proponent	ConocoPhillips Australia Exploration Pty Ltd. (ConocoPhillips)
Location	Barossa offshore development area: Approximately 300 km north of Darwin, approximately 227 km offshore (nearest point to mainland) and approximately 100 km north of the Tiwi Islands. Gas export pipeline corridor: Connecting the Barossa offshore development area to the existing Bayu-Undan to Darwin gas export pipeline in Commonwealth waters to the south-west of the Tiwi Islands.
Relevant jurisdictions	Commonwealth Government; NT Government (unplanned activities only)
Water depths	Barossa offshore development area: 130 metres (m)–350 m Gas export pipeline corridor: ranging from approximately 30 m to 240 m, with the exception of a shallow water area (approximately 30 km long) immediately east of the Oceanic Shoals marine park where minimum water depths may be as shallow as approximately 5 m

Development characteristics	• Floating Production Storage and Offloading (FPSO) facility • Subsea production system tied back to the FPSO facility • Gas export pipeline with proposed tie-back connection to the existing Bayu-Undan to Darwin gas export pipeline • Supporting infrastructure for full field development, including fibre optic cable
Anticipated hydrocarbon	Natural gas and light condensate
Approximate LNG production rate	3.7 million tonnes per annum (Mtpa)
Approximate condensate production rate	1.5 million barrels per year (MMbbl/yr)
Final investment decision	Target 2019
Operating life	Approximately 25 years
First gas	Target 2023

The development concept includes a permanently moored FPSO facility, subsea production system, supporting in-field subsea infrastructure and a gas export pipeline, located exclusively in Commonwealth waters. The FPSO facility will undertake offshore preliminary processing of the reservoir fluids (i.e. hydrocarbons) extracted from the field into separate dry gas and condensate products. It is proposed that the dry gas will then be transported via a new approximately 260 km–290 km long gas export pipeline from the Barossa offshore development area and subject to suitable commercial arrangements being put in place, tie-in to the existing Bayu-Undan to Darwin pipeline for transport to Darwin for onshore LNG processing (**Figure 1-1**). As the new gas export pipeline route is still subject to refinement, a corridor has been identified for the purposes of this OPP to allow flexibility for placement pending further engineering and environmental investigations. The condensate will be exported periodically from the FPSO facility to offtake tankers in the Barossa offshore development area.

While the development concept is in Commonwealth waters, some general aspects of the project have the potential to fall under the jurisdiction of NT legislation. For example, supply vessels may transit through NT waters, and some wastes generated by the project will require onshore management and disposal. Consideration of aspects that fall under NT approvals (including assessing the impacts and risks from those aspects) are outside the scope of this OPP (**Section 4.2.1.1**) and are not considered further in this document as they are subject to separate permitting arrangements.

Furthermore, any modifications related to the onshore DLNG facility for processing the dry gas into LNG is outside the scope of this OPP.

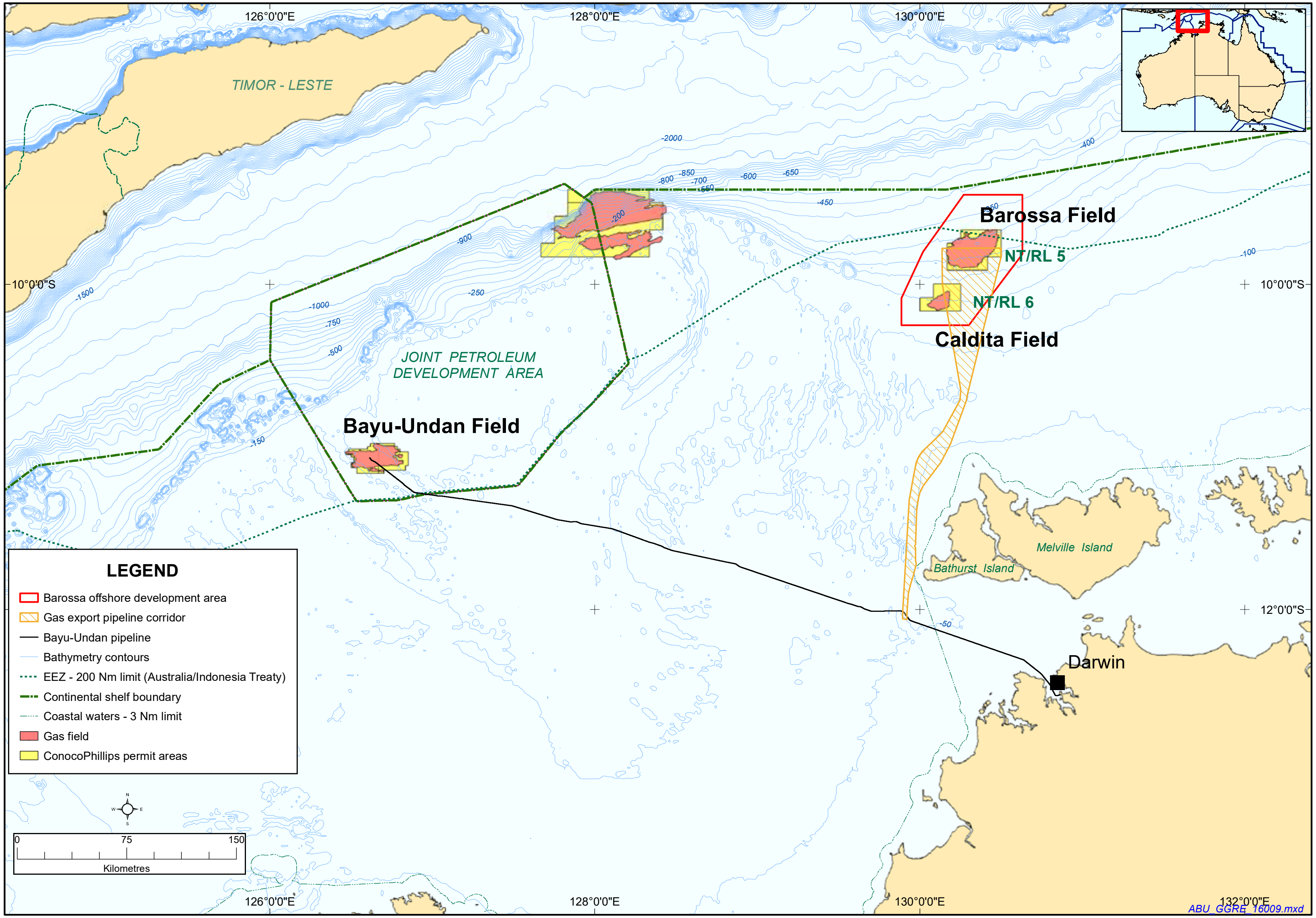


Figure 1-1: Project location

1.2 Purpose and structure of document

This OPP has been prepared in accordance with the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regulations), administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act).

The OPP is intended to be an early-phase environmental assessment of the offshore development, at a whole-of-project life-cycle level.

The purpose of this OPP, in alignment with the NOPSEMA OPP Content Requirements Guidance Note (herein referred to as the 'OPP Guidance Note' (NOPSEMA 2016a), is to:

- demonstrate that ConocoPhillips understands the requirements of the OPGGS (E) Regulations
- provide NOPSEMA and other interested stakeholders with the information required to assess the project against the requirements of the OPGGS Act and associated regulations, including description of the project, feasible alternatives to the project and the existing environment (including any relevant values and sensitivities) that may be affected
- identify the nature and scale of potential environmental impacts and risks associated with the project
- define environmental performance outcomes (EPOs) that will allow the impacts and risks to be managed to an acceptable level
- provide the public an opportunity to review and provide input at an early stage of the proposed project.

The OPP also seeks to provide a level of assessment that delivers environmental outcomes equivalent to the assessment processes under the *Environment Protection and Biodiversity Conservation Act 1999 Act* (EPBC Act) (NOPSEMA 2016b). It achieves this through the requirement to *"identify, assess and consult on all the potential impacts to matters protected under Part 3 of the EPBC Act and the broader environment in a systematic way, which is consistent with environmental impact assessment processes"* (NOPSEMA 2016b).

The proponent of an OPP must demonstrate environmental impacts and risks will be managed to an acceptable level. The acceptance of an OPP does not provide approval for offshore development activities to commence; rather, it provides approval for the submission of the Environment Plans (EPs) for project activities (NOPSEMA 2016b). A project activity cannot commence until a NOPSEMA accepted EP is in place. The nominated titleholder is responsible for submission of the EPs and compliance with the OPGGS Act and OPGGS (E) Regulations during implementation of the petroleum activity. The titleholder must demonstrate in the activity-specific EPs that environmental impacts and risks will be managed to a level that is both acceptable and as low as reasonably practicable (ALARP).

The structure of the OPP and the relevant sections of the OPGGS (E) Regulations are shown in **Table 1-2**.

Table 1-2: OPP structure, content and relevant sections of the OPGGS (E) regulations

OPGGS (E) regulation	Requirements	OPP section
Regulation 5A Submission of an Offshore Project Proposal		
5A (5) (a)	Include the proponent's name and contact details.	Section 1.3 and Section 1.4
5A (5) (b)	Include a summary of the project, including the following: (i) a description of each activity that is part of the project; (ii) the location or locations of each activity; (iii) a proposed timetable for carrying out the project; (iv) a description of the facilities that are proposed to be used to undertake each activity; and (v) a description of the actions proposed to be taken, following completion of the project, in relation to those facilities.	Section 4
5A (5) (c)	Describe the existing environment that may be affected by the project.	Section 5
5A (5) (d)	Include details of the particular relevant values and sensitivities (if any) of that environment.	Section 5
5A (5) (e)	Set out the environmental performance outcomes for the project.	Section 7
5A (5) (f)	Describe any feasible alternative to the project, or an activity that is part of the project, including: (i) a comparison of the environmental impacts and risks arising from the project or activity and the alternative; and (ii) an explanation, in adequate detail, of why the alternative was not preferred.	Section 4.4
5A (6)	Requirement to address particular relevant values and sensitivities [as defined in the EPBC Act].	Section 5
5A (7)	The proposal must: a) describe the requirements, including legislative requirements, that apply to the project and are relevant to the environmental management of the project; and b) describe how those requirements will be met.	Section 2 and Section 3
5A (8)	The proposal must include: a) details of the environmental impacts and risks for the project; and b) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk.	Section 6
Regulation 11A Consultation with relevant authorities, persons and organisations, etc.		
11A	Consultation with relevant authorities, persons and organisations. [Note while this regulation relates specifically to consultation required for an EP, the general intent can be applied to an OPP]	Section 8

1.3 Description of proponent

For this OPP, ConocoPhillips is the proponent for the offshore project, and as Operator of NT/RL5 and NT/RL6, will most likely be the nominated titleholder (i.e. petroleum production and pipeline licensee) that submits subsequent EPs for implementation of activities undertaken as part of the project, as required under Regulation 4 of the OPGGS (E) Regulations.

ConocoPhillips Company (United States) is the world's largest independent exploration and production company. Through various Australian registered company subsidiaries, ConocoPhillips Company undertakes exploration activities, and holds and operates assets in the Timor Sea, NT, Western Australia (WA) and Queensland. ConocoPhillips has been operating in Australia and the Joint Petroleum Development Area since the mid-1990s. Its activities in Australia are currently managed, operated and administered through its Australian Business Units (BUs): Australia Business Unit-West (ABU-W) and Australia Business Unit-East (ABU-E). The Bayu-Undan gas condensate field in the Timor Sea, the DLNG facility in the NT and the 502 km gas export pipeline linking the two facilities are operated by ConocoPhillips from ABU-W. ABU-W has also been safely and successfully undertaking exploration and appraisal activities (including drilling) in its offshore acreage in both the Bonaparte Basin and the Browse Basin.

Australia Pacific LNG facilities located on Curtis Island in Queensland are operated by ConocoPhillips from ABU-E

1.4 Proponent contact details

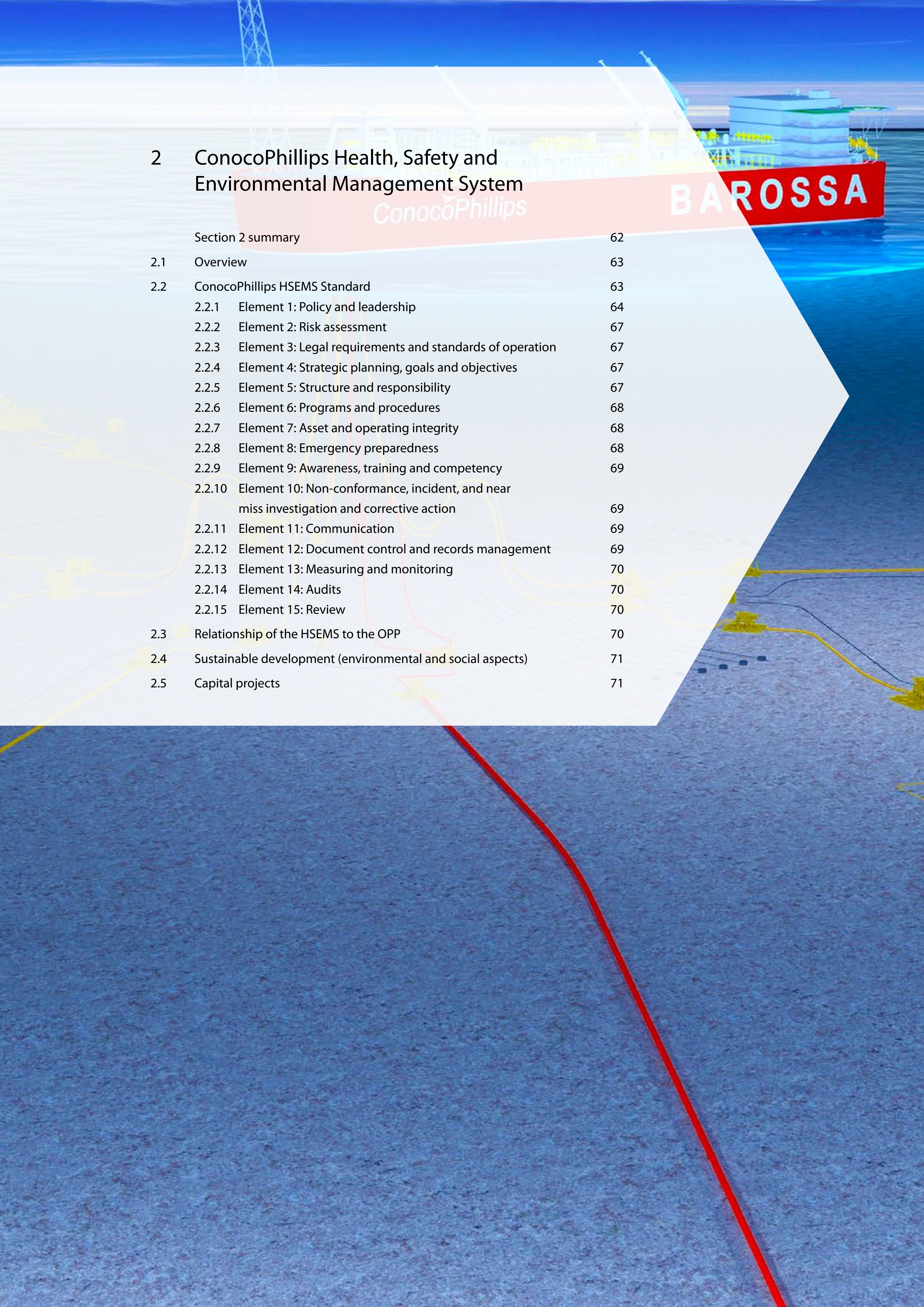
ConocoPhillips, as proponent of this OPP, can be contacted at:

Barossa Area Development Project

Phone: + 61 8 9423 6666

Email: barossa@conocophillips.com

Street address	Mailing address
Senior Environmental Specialist, Barossa Area Development Project	Senior Environmental Specialist, Barossa Area Development Project
53 Ord Street, West Perth	ConocoPhillips Australia Exploration Pty Ltd.
Western Australia, 6005	PO Box 1102, West Perth
	Western Australia, 6872



2 ConocoPhillips Health, Safety and Environmental Management System

Section 2 summary

Purpose:

This section describes the management system that ConocoPhillips will use to incorporate the commitments made for the project into its daily business and operations.

Section at a glance:

ConocoPhillips will manage the project in the same way the company approaches all its capital projects throughout the world. This ensures consistency of approach and application of the company's principles for protection of the environment, health and safety, as well as our commitments to environmentally sustainable development.

Our Health, Safety and Environmental Management System (HSEMS) provides the operating framework within which tools such as standards, procedures and policies are used to manage impacts and risks. The HSEMS also provides the framework for delivering the commitments, referred to as environmental performance outcomes, that are made in **Section 7** of this document.

Throughout all stages of a project the HSEMS identifies the processes, methods and work practices that will be used to achieve the stated outcomes and operate safely, reliably and efficiently. The HSEMS includes company policies, procedures, standards, practices, guidelines, training and operator manuals and templates.

The system involves continuous review and improvement in the way managers and employees interact, train, communicate, evaluate, plan and carry out every aspect of their jobs. Above all else, the system is continually focused on managing impact and risk to ensure the safety of employees, the community and the environment.

2 ConocoPhillips Health, Safety and Environmental Management System

2.1 Overview

At ConocoPhillips, a Health, Safety and Environmental Management System (HSEMS) provides a systematic process to identify, assess, and manage health, safety and environmental risks from and to business operations. The routine application of a HSEMS provides ongoing identification, prioritisation and control of these risks.

In support of the HSEMS, ConocoPhillips has a Sustainable Development Risk Management Practice that promotes the realisation of economic, social and environmental benefits through the project life. Refer to **Section 2.4** for further detail.

For capital projects, such as this project, ConocoPhillips also implements a Capital Project Management System (CPMS) which supports the HSEMS and provides a framework for the successful execution and management of a project. The CPMS is discussed in detail in **Section 2.5**.

2.2 ConocoPhillips HSEMS Standard

The ConocoPhillips HSEMS Standard guides the implementation of the HSEMS within individual business units across ConocoPhillips global operations. It has four distinct phases and 15 interrelated elements, as shown in **Figure 2-1**, with each phase of the process building on the previous phases.

- PLAN: hazards, risks, and regulatory requirements are identified in these elements. These elements also identify the risk mitigation requirements that will be built-out in the DO phase and provide for the establishment of strategic plans, goals and objectives
- DO: describes the specific implementation tools needed to manage the risks and requirements identified in the PLAN phase
- ASSESS: describes detailed monitoring and auditing to ensure that risks and requirements are being identified, assessed, and managed
- ADJUST: provides for modification of the HSEMS and its implementation in order to adjust for strengths, gaps and opportunities for improvement identified in the ASSESS phase.

The HSEMS Standard defines the framework and requirements for each element within the HSEMS, to ensure that HSE issues are managed in a consistent manner across ConocoPhillips, and establishes a risk-based, risk-appropriate, targeted improvement process.

The 15 elements of the HSEMS and their implementation are discussed in detail in **Section 2.2.1** to **Section 2.2.15**.

Figure 2-1: Overview of ConocoPhillips HSEMS

2.2.1 Element 1: Policy and leadership

This element defines expectations for the HSE Policy and leadership requirements for supporting a strong HSE culture, ensuring compliance with HSE requirements and driving HSE excellence.

ConocoPhillips HSE Policy, as shown in **Figure 2-2**, establishes the expectations, principles of operation and desired outcomes for the Company. The HSE Policy is supported by a Sustainable Development Position Statement, as shown in **Figure 2-3**.

2.2.2 Element 2: Risk assessment

This element defines HSE risk management requirements, inclusive of sustainable development considerations. ConocoPhillips seeks to maintain the health and safety of its employees and contractors, and minimise environmental impact and risk through the active and progressive elimination of hazards and the reduction of risk to a level that is ALARP.

The core steps of HSE and sustainable development risk management include:

- define the context, including risk acceptability criteria and the task/activity
- identify the hazards to determine risk scenarios
- analyse the risk using either quantitative or qualitative assessments
- evaluate the risk using the ConocoPhillips Risk Matrix
- manage and reduce risk to ALARP (eliminate, substitute, engineering and administrative controls)
- continuously monitor and review the risk
- communicate identified risks via risk registers and consultation with personnel.

The environmental risk management framework is embedded within the HSEMS and the core steps described above applied to the assessment and management of environmental impacts and risks. A full summary of the environmental risk management approach undertaken for this OPP is provided in **Section 6**.

Further description of how ConocoPhillips incorporates sustainable development into risk management is provided in **Section 2.4**.

ConocoPhillips

HEALTH, SAFETY AND ENVIRONMENT POLICY

Our Commitment

ConocoPhillips is committed to protecting the health and safety of everybody who plays a part in our operations, lives in the communities in which we operate or uses our products. Wherever we operate, we will conduct our business with respect and care for both the local and global environment and systematically manage risks to drive sustainable business growth. We will not be satisfied until we succeed in eliminating all injuries, occupational illnesses, unsafe practices and incidents of environmental harm from our activities.

Our Plan

To meet our commitment, ConocoPhillips will:

- Demonstrate visible and active leadership that engages employees and services providers and manage health, safety and environmental (HSE) performance as a line responsibility with clear authorities and accountabilities.
- Ensure that all employees and contractors understand that working safely is a condition of employment, and that they are each responsible for their own safety and the safety of those around them.
- Maintain "stop work" policies that establish the responsibility and authority for all employees and contractors to stop work they believe to be unsafe.
- Manage all projects, products and processes through their life cycles in a way that protects safety and health and minimizes impacts on the environment.
- Provide employees with the capabilities, knowledge and resources necessary to instill personal ownership and motivation to achieve HSE excellence.
- Provide relevant safety and health information to contractors and require them to provide proper training for the safe, environmentally sound performance of their work.
- Measure, audit and publicly report HSE performance and maintain open dialogue with stakeholder groups and with communities where we operate.
- Comply with applicable regulations and laws.
- Work with both governments and stakeholders where we operate to develop regulations and standards that improve the safety and health of people and the environment.
- Maintain a secure work environment to protect ourselves, our contractors and the Company's assets from risks of injury, property loss or damage resulting from hostile acts.
- Communicate our commitment to this policy to our subsidiaries, affiliates, contractors and governments worldwide and seek their support.

Our Expectations

Through implementation of this policy, ConocoPhillips seeks to earn the public's trust and to be recognized as the leader in HSE performance.

Ryan Lance
Chairman and Chief Executive Officer
ConocoPhillips

Figure 2-2: ConocoPhillips HSE Policy

ConocoPhillips

SUSTAINABLE DEVELOPMENT POSITION

Sustainable Development is about conducting our business to promote economic growth, a healthy environment and vibrant communities, now and into the future. We believe that this approach will enable us to deliver long-term value and satisfaction to our shareholders and our stakeholders.

Sustainable Development is fully aligned with our vision, to be the E&P company of choice for all stakeholders by pioneering a new standard of excellence, and our SPIRIT Values.

OUR FOCUS

To deliver on our commitments, we will prioritize issues, establish plans for action with clear goals and monitor our performance. In addition, we will develop the following company-wide competencies to successfully promote sustainable development:

- Integration — Clearly and completely integrate economic, social and environmental considerations into strategic planning, decision-making and operating processes.
- Stakeholder Engagement — Engage our stakeholders to understand their diverse and evolving expectations and incorporate that understanding into our strategies.
- Life-Cycle Management — Manage the full life-cycle impacts of our operations, assets, and products.
- Knowledge Management — Share our successes and failures to learn from our experiences.
- Innovation — Create a culture that brings new, innovative thinking to the challenges of our evolving business environment.

OUR EXPECTATIONS

Through delivering on our commitments to sustainable development, we will be the best company to have as a supplier, investment, employer, partner and neighbor.

Figure 2-3: ConocoPhillips Sustainable Development Position

Operational safety

The identification and understanding of hazards that exist in ConocoPhillips operated or leased facilities, including those related to design, construction, installation, commissioning, operations and decommissioning of facilities (i.e. life-cycle assessment), are fundamental prerequisites to managing those hazards. Throughout a project, there are systematic safety studies done by multi-discipline teams in order to reduce any identified risk levels to ALARP. This is particularly important in the design phase as there is the opportunity to 'design out' or eliminate hazards through the application of the hierarchy of controls, to make the facilities inherently safer.

Risk assessments undertaken throughout the project life shall consider planned, unplanned and emergency operating conditions. When the assessment process is complete, relevant personnel shall be informed of the risks identified and the control measures necessary to eliminate, reduce or control the risks to ALARP. The assessment output shall be documented in appropriate risk registers and resulting action plans. Mitigation measures shall be assigned to responsible parties and target close-out dates established. These shall be subject to periodic review and update as required throughout the project life-cycle. All actions resulting from these studies shall be closed out with adequate supporting documentation prior to implementation of the related works.

2.2.3 Element 3: Legal requirements and standards of operation

This element establishes requirements for maintaining a process to monitor changing laws/regulations and site activities, and assigning responsibilities to help assure compliance with legal requirements (e.g. laws, regulations, permits or project approvals and commitments made in permit applications) and standards of operation (e.g. relevant ConocoPhillips and industry standards and/or design codes) applicable to the operational jurisdiction.

All aspects of the project operations (including project design, installation, pre-commissioning, commissioning, operation and decommissioning) will be compliant with relevant International, Commonwealth, State and Territory requirements, codes and standards of operation.

The environmental legislation and other environmental management requirements relevant to the project are discussed in detail in **Section 3**.

2.2.4 Element 4: Strategic planning, goals and objectives

This element establishes the requirements for HSE planning and goal setting.

In the context of this OPP, the environmental performance outcomes, detailed in **Section 7**, represent the environmental goals or objectives for the project.

2.2.5 Element 5: Structure and responsibility

This element establishes requirements to define and manage roles, responsibilities, accountabilities, employee engagement, and interrelationships.

ConocoPhillips maintains a structured organisation to manage all potential impacts and risks of Company activities as relevant to HSE aspects, including:

- documenting roles, responsibilities and accountabilities as they relate to the HSEMS
- defining an effective method of communication to ensure understanding of roles, responsibilities, and accountabilities
- providing the resources and structure essential for implementation, operation, and maintenance of the HSEMS.

2.2.6 Element 6: Programs and procedures

This element establishes requirements to develop and implement programs and documented procedures to ensure compliance with legal requirements and standards of operation, and to manage HSE risks. These programs, processes and procedures are made available to relevant employees and contractors and are reviewed at an appropriate BU level in accordance with a defined review schedule. Programs and procedures are central to implementation of the HSEMS.

Programs are implemented to manage and communicate permanent and temporary changes associated with project impacts and risks. Any change shall be formally assessed, managed, implemented, documented, approved and closed out in accordance with the project procedure.

2.2.7 Element 7: Asset and operating integrity

This element establishes standards for development, implementation and maintenance of ConocoPhillips Asset and Operating Integrity (A&OI) programs to:

- properly manage risks associated with operations, equipment failure or uncontrolled loss of primary containment
- establish a clear understanding of operated assets, failure mechanisms and their consequences/associated risks.

The A&OI philosophy is communicated and fully integrated through the implementation of various A&OI programs, processes and procedures that define and manage the integrity of ConocoPhillips operated/leased assets and operations across the project life-cycle. These programs and procedures include:

- procurement and pre-construction HSE assessment (e.g. design considerations)
- identifying and documenting major accident hazards, safety critical elements and technical performance requirements
- design and engineering documentation, which covers design and construction, decommissioning and abandonment, procurements and third party services, quality assurance/quality control verification and inspection, testing, and maintenance programs
- commissioning and pre-start up reviews
- structural integrity systems
- hazard identification and risk analyses
- operating and maintenance procedures and programs
- management of change procedures.

The A&OI programs are reviewed and updated by technically competent personnel to manage the risks associated with the asset life-cycle. This process involves application of appropriate controls and A&OI integrity management performance measures, and engagement of ConocoPhillips personnel/contractors through communication of the aims and goals established for the management of technical integrity.

2.2.8 Element 8: Emergency preparedness

This element defines the Crisis Management and Emergency Response (CM&ER) planning and preparedness requirements for assets operated by ConocoPhillips and the Crisis Management support functions provided and coordinated from ConocoPhillips Headquarters.

Each site is covered by facility and project specific CM&ER processes and systems to appropriately address identified risks and applicable legal requirements. These risks are identified via appropriate systematic review and analysis processes, as outlined in **Section 2.2.2**.

A Crisis Management Plan (CMP) is maintained that provides the structure and procedures whereby resources and support can be rapidly assembled and allocated to supplement actions taken at the emergency site. Crisis and emergency response is managed by a hierarchy of teams within the Company and includes a Crisis Management Team (and support team) and Incident Management Assist Team. The CMP is supplemented by sub-ordinate Incident Management Plans (IMPs) and activity-specific OPEPs.

Further details on emergency response and preparedness are provided in **Section 7.2.2**.

2.2.9 Element 9: Awareness, training and competency

This element establishes the requirement that all employees, contractors, and visitors have the necessary awareness, training, and competency to perform their activities consistent with Company HSE Policy, standards, and procedures.

ConocoPhillips implements a documented training and competency system to confirm that employees/contractors have the required training and competency to fulfil their duties in a safe, environmentally and socially responsible manner. The system addresses:

- employee selection and identification of training, competence and development needs
- contractor evaluation and management
- operator or mechanical skills training and qualification
- development and maintenance of training resources and records
- demonstration of competency.

2.2.10 Element 10: Non-conformance, incident, and near miss investigation and corrective action

Through this element, a systematic approach is implemented so that all incidents and near misses are consistently, methodically and effectively investigated as appropriate to their risk or potential severity. All incidents, including near misses, are reported, investigated in a timely manner and analysed to identify corrective actions/preventative measures to prevent recurrence and continuously improve HSE performance. Incident investigations are documented using a database to track actions and enable sharing of learnings.

Non-conformances may be identified through audits (**Section 2.2.14**), observations or incident reports. Actions to address non-conformances are developed following the same process applied to address root causes of incidents.

Key performance indicators are in place to track and report the status of actions arising from incidents and audits.

Reporting specific to OPGGS (Environment) Regulations

Subject to OPP approval, subsequent EPs covering the project activities will identify reportable and recordable incidents for the particular activities in accordance with OPGGS (E) Regulation 26, 26(A), 26(AA) and 26(B), and will outline processes for reporting as per Regulation 26(C). Environmental incidents will be reported to the appropriate government authorities when required.

2.2.11 Element 11: Communication

This element sets the requirements for the communication of information within the Company and engagement with external stakeholders.

Internal communication

Dedicated processes and procedures facilitate the effective internal communication of HSE and Sustainable Development (HSE&SD) related issues at ConocoPhillips corporate, Business Unit, project and operations levels. Examples include, but are not limited to, BU HSEMS manual and procedures; office and facility inductions; HSE intranet websites and performance metrics; programs and procedures; HSE bulletins and safety moments; hazard reporting and issue resolution procedures; and training programs and processes.

External communication

ConocoPhillips is committed to ongoing, active, transparent and collaborative consultation with stakeholders throughout the life-cycle of its projects and operations. Accordingly, processes and procedures have been developed to manage stakeholder relations via open communication, in order to understand and respond appropriately to their diverse and evolving expectations.

External communication processes define responsibility and chain of control for receiving and handling inquiries and tracking receipt, response, and status of inquiries from external parties.

Refer to **Section 8** for an overview of the consultation program relevant to this OPP.

2.2.12 Element 12: Document control and records management

This element establishes the requirements for management and control of HSEMS documents and records. Procedures are implemented to manage key documentation and to ensure that documents are accurate, current and available to appropriate personnel. Documents and records, including procedures, work instructions and other information necessary to carry out work activities, are retained in accordance with corporate and legislative requirements. Documents are also reviewed at a defined frequency and revised as necessary, with current versions made available and obsolete documents removed or identified and retained (where necessary) for legal use.

2.2.13 Element 13: Measuring and monitoring

This element defines the requirements for measuring and monitoring BU performance, providing assurance of compliance, assessing effectiveness in meeting the Company's goals and legal obligations, and identifying opportunities for improvement.

Processes are implemented for measuring and monitoring HSE performance, evaluating the achievement of HSE goals and objectives, identifying opportunities for improvement and providing assurance of compliance. Leading and lagging performance measures are developed, identified, tracked and reported to provide timely information to manage trends and impacts and to establish future goals and direction. Processes are also in place to measure and monitor project operations and activities.

2.2.14 Element 14: Audits

This element establishes requirements for audit programs that assess the adequacy and effectiveness of HSE controls. The audit program also identifies any non-conformances within the HSEMS.

ConocoPhillips implements and maintains a program for the planning/scheduling, preparation, execution, reporting and close-out of HSE audits carried out across all areas of BU operations including capital projects. The program also includes a process to analyse non-conformance to identify underlying cause(s) and/or management system failures, and provisions for periodic review.

2.2.15 Element 15: Review

This element establishes requirements to review the content and functionality of the HSEMS to ensure there is a functioning and systematic process in place so that HSE&SD risks are identified and managed in order to achieve the Company and BU HSE&SD goals and objectives.

With participation from the most senior leadership positions, the BUs implement a documented annual HSE and A&OI Review Process for the review of the BU HSEMS. The reviews are conducted by defined groups, teams, or committees (including HSE Steering Committees), with results reported to, and reviewed by, BU management.

The review process takes into account applicable HSEMS data and outputs and considers:

- results of internal audits and evaluations of compliance with legal and other requirements
- communications from external interested parties, including complaints
- the environmental performance of the organisation
- the extent to which objectives and targets have been met in light of changing circumstances and commitment to continuous improvement
- status of corrective and preventive actions from investigations and audits
- follow-up actions from previous management reviews
- significant issues from risk assessments
- incidents
- recommendations for improvement.

The outcomes and decisions made in these reviews are distributed to relevant management and planning teams. This ensures that the 'adjust' phase of the HSEMS process may feed into the 'plan' phase, closing the loop on the 'PLAN, DO, ASSESS and ADJUST' cycle of continuous improvement (**Figure 2-1**).

2.3 Relationship of the HSEMS to the OPP

The HSEMS provides the framework that ConocoPhillips follows to systematically identify, assess and manage HSE aspects. In the context of this OPP, the HSEMS provides a framework to identify, assess and manage environmental impacts and risks. The OPP is intended to be built around the framework of the ConocoPhillips HSEMS to ensure environmental performance outcomes (EPOs) are reflective of core HSEMS processes and integrated into Company activities and operations.

Within the HSEMS framework, the OPP is designed to:

- define and assess all environmental impacts and risks associated with the nature and scale of the project
- define EPOs
- provide a road map to the relevant HSEMS documentation to demonstrate application of the HSEMS to manage environmental impacts and risks to an acceptable level
- provide early strategic assessment to inform decision-making in the formative engineering stages of the project definition to achieve acceptable environmental outcomes
- identify key, high level mitigation measures for the project to be delivered through the HSEMS and subsequent activity-specific EPs.

2.4 Sustainable development (environmental and social aspects)

As part of implementing its approach to sustainable development, ConocoPhillips commits to clearly and completely integrating economic, social and environmental considerations into project development and decision-making. Sustainable development processes are developed in compliance with the ConocoPhillips Sustainable Development Risk Management Practice and the ConocoPhillips HSE and Social Issues Due Diligence Standard to assess:

- transparency and accountability by measuring and reporting
- operating to the highest safety standard
- minimising the environmental impact of ConocoPhillips' operations
- positively impacting communities wherever ConocoPhillips operates
- investing in the well-being and development of the ConocoPhillips workforce
- energy and material efficiency of ConocoPhillips operations
- practicing and upholding the highest ethical standards
- ensuring the long-term financial viability of the Company.

The ConocoPhillips Sustainable Development Scorecard is a tool that can be used to summarise the potential project risks and mitigation actions related to climate change, stakeholder engagement, water and biodiversity.

2.5 Capital projects

The ConocoPhillips CPMS, together with the HSEMS, provides a suite of standards, practices, guidelines and templates that offer a flexible framework for developing and executing capital projects. The CPMS and HSEMS facilitate this through the timely and appropriate use of proven industry standards and tools, including establishment of overall requirements for project development and management.

The CPMS defines the minimum requirements for assessing environmental and social risks in the management of capital projects and includes requirements to conduct environmental risk assessments and topic-specific risk assessments for climate change, water and biodiversity, as well as the social performance plan requirements.

The HSE&SD goals and objectives for capital projects, and the associated work plans for accomplishing these, are developed in accordance with the CPMS, HSEMS and the ConocoPhillips Sustainable Development Risk Management Practice, which provides a consistent approach to identify and reduce social and environmental risks. Together these enable the successful management of HSE&SD (including the environmental approvals process) throughout the life-cycle of the project.

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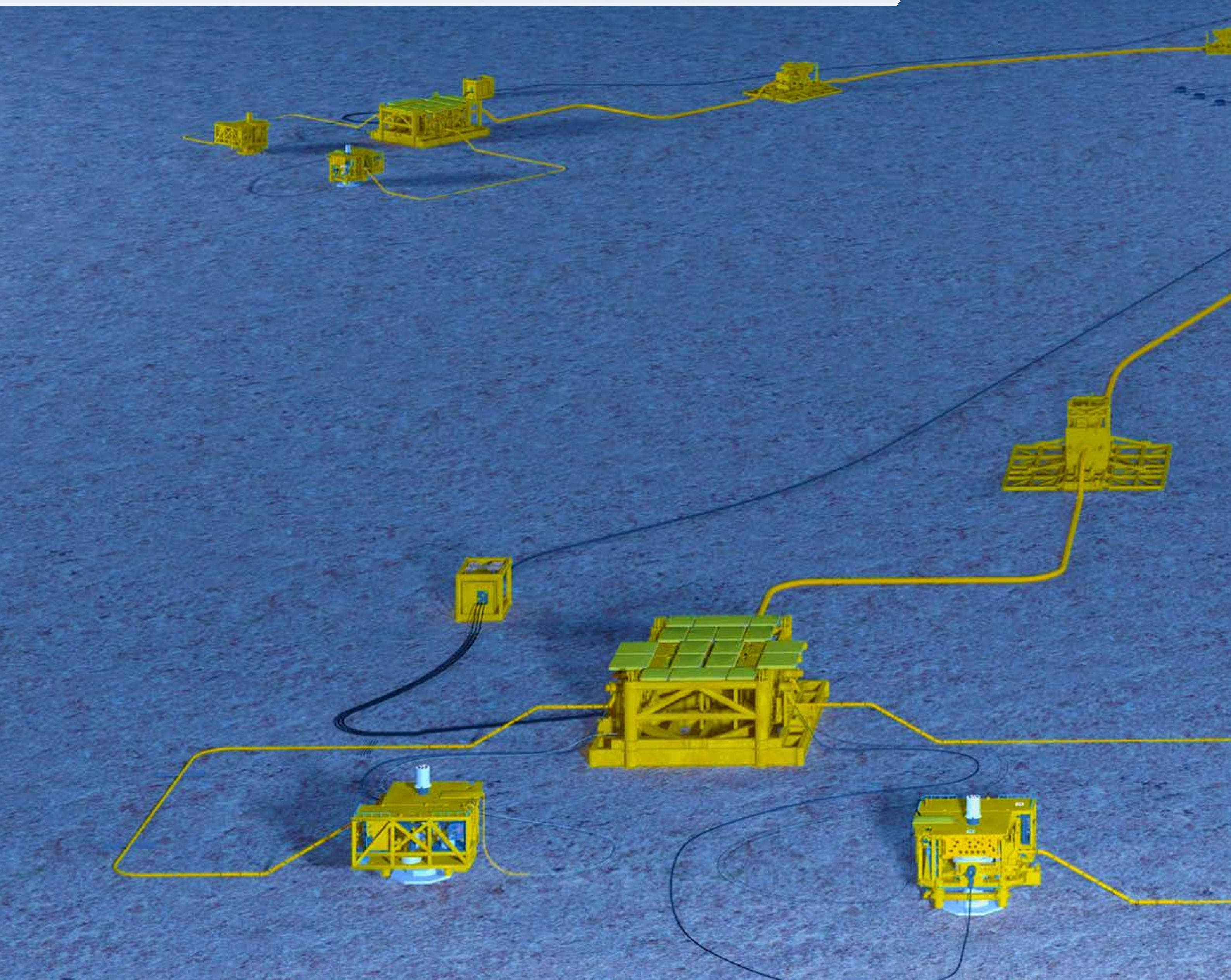
3 Environmental legislation and other environmental management requirements



Section 3 summary

Purpose:

This section describes the legislation and other requirements that will apply to the project and their relevance to environmental management. It also describes other approvals that will be required at future stages of the project and how forward environmental approvals align with the project's development stages.

Section at a glance:

The project is located in Commonwealth waters and subject to Commonwealth laws, as well as international agreements, conventions and treaties that are in place to protect the environment, conserve biodiversity, and ensure safe and responsible practices at sea. The project will also align with applicable guidelines and codes of practice, including all relevant management and recovery plans for matters of national environmental significance listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Brief summaries of each relevant Act, agreement and treaty as they relate to the project, are described below.

The two main pieces of Commonwealth legislation that apply to the project are the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and the EPBC Act. The OPGGS Act provides protection of the environment in Commonwealth waters through management of all relevant oil and gas activities, and requires the development of this document. The EPBC Act provides the legislative framework to protect and manage threatened species, ecological communities or listed places from actions that have a significant impact. These are identified and discussed in detail in **Section 5** and **Section 6** of this document.

Once an OPP is accepted, activity-specific Environment Plans (EPs) and Oil Pollution Emergency Plans (OPEPs) are required to be submitted to and accepted by NOPSEMA before commencing an activity. The EPs will provide further evaluation of the impacts and risks associated with specific activities, while the OPEPs detail arrangements for responding to and monitoring oil pollution.

Other approvals and plans that will be required in the future include production, pipeline and infrastructure licences, Safety Cases for vessels and management plans for well operations.

3 Environmental legislation and other environmental management requirements

Applicable legislation and environmental management frameworks are summarised below. ConocoPhillips, like all operators, is responsible for maintaining currency of applicable legal requirements as relevant to the proposal. The key relevant legislative requirements are referenced as appropriate to frame the management measures for environmental impacts and risks presented in **Section 6.4**, and summarised in **Section 7**.

3.1 Commonwealth legislation

The project is located in Australian Commonwealth waters and is, therefore, subject to Commonwealth legislation. The following sections outline the key Commonwealth legislation applicable to the project.

3.1.1 OPGGS Act 2006

The OPGGS Act provides protection of the environment in Commonwealth waters (as well as designated State and NT waters where functions have been conferred), by ensuring that all offshore petroleum and greenhouse gas storage activities are undertaken in a manner where impacts and risks on the environment, including those Matters of National Environmental Significance (MNES) protected under Part 3 of the EPBC Act, are of an acceptable level and reduced to ALARP. The OPGGS Act requires all activities to be consistent with the principles of ecologically sustainable development (ESD), as defined in the EPBC Act (Section 3A):

- *"decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;*
- *if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation ;*
- *the principle of inter-generational equity: that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;*
- *the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making;*
- *improved valuation, pricing and incentive mechanisms should be promoted."*

The OPGGS Act is supported by a range of subordinate regulations. Of primary relevance to this OPP are the OPGGS (E) Regulations, which provide further definition and guidance on the environmental management of offshore petroleum and greenhouse gas storage activities. The OPGGS Act and supporting regulations are administered by NOPSEMA.

Beyond this OPP, other approvals required under the OPGGS Act and associated regulations include the following:

- Environment Plans (EPs)
- Oil Pollution Emergency Plans (OPEPs)
- production licences
- pipeline licences
- infrastructure licences
- Safety Cases
- Well Operations Management Plan (WOMP)
- petroleum safety zones.

[1] This refers to the precautionary principle, which is defined in Section 391(2) of the EPBC Act as *"is that lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage".*

Figure 3-1 provides an indicative timeframe of how this OPP, activity-specific EPs/OPEPs and other approvals fit into ConocoPhillips' project phases. As OPP submission occurs early in the design phase, detailed engineering design is yet to be completed for the project. More specific details (e.g. timing and methodology) of project activities will be refined during the 'Define' (front end engineering design (FEED)) and 'Execute' Phases of the project (refer to **Figure 3-1**).

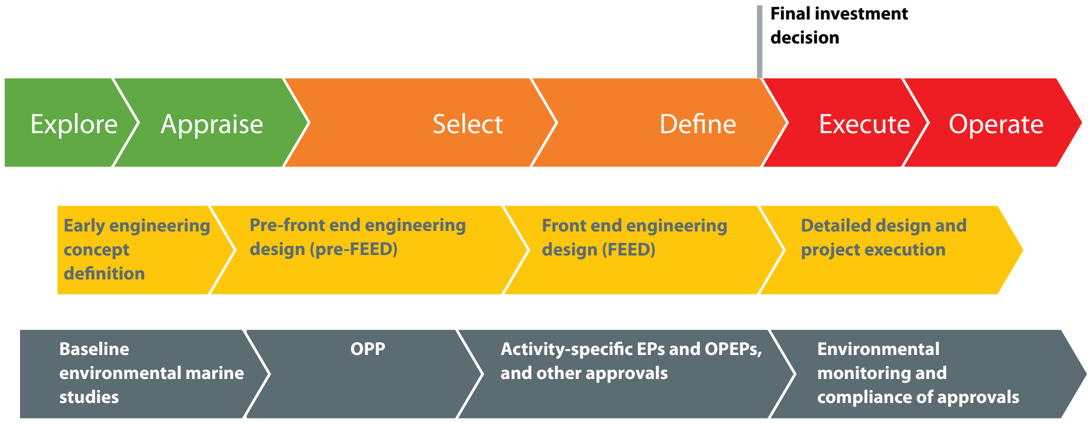


Figure 3-1: ConocoPhillips project phases and OPGGS Act approvals

Activity-specific Environment Plan

Under the OPGGS (E) Regulations, the titleholder is required to submit an EP before commencing an activity and the activity cannot take place until the regulator accepts the EP. The EP must be appropriate for the nature and scale of the activity and describe the activity, the existing environment, details of environmental impacts and risks and the control measures for the activity. In addition, the EP must include an implementation strategy to demonstrate that the impacts and risks can be managed to ALARP and an acceptable level and to describe how appropriate environmental performance outcomes, standards and measurement criteria outlined in the EP will be met. The EP will also provide a summary of all consultation undertaken with relevant persons.

ConocoPhillips will prepare and submit activity-specific EPs in accordance with the OPGGS (E) Regulations. It is envisaged that a series of EPs will be developed to cover the following project activities:

- development drilling
- subsea structure installation (including gas export pipeline installation)
- tow-out and hook up of the FPSO facility
- commissioning
- operations
- decommissioning.

Oil Pollution Emergency Plan

Under the OPGGS (E) Regulations, an OPEP is required as part of the implementation strategy for the activity-specific EP. The OPEP must include adequate arrangements for responding to and monitoring oil pollution as well as provision for updating the plan. Preliminary hydrocarbon spill modelling has been carried out for a number of maximum credible spill scenarios associated with various stages of the project (discussed in **Section 6**) and will provide support in framing the scope of future OPEPs.

Other approvals

As listed above, other approvals will be required for the project, including, but not limited to, a production licence, a pipeline licence and an infrastructure licence. These approvals are required under the OPGGS Act for the relevant activities and are granted by the Joint Authority[2].

The OPGGS (Resource Management and Administration) Regulations 2011 also require that a Safety Case and a WOMP are assessed and accepted by NOPSEMA for existing or proposed facilities. ConocoPhillips will prepare and submit the required Safety Cases and Well Operations Management Plans to NOPSEMA as the project is developed, to allow for timely approvals prior to each of the key stages of the project. These approvals assist in environmental protection as they ensure the integrity of the development wells, mobile offshore drilling unit (MODU)/drill ship, FPSO facility and project vessels.

[2] The Joint Authority for an offshore area is constituted by the responsible State (with the exception of Tasmania) or Territory Minister and the responsible Commonwealth Minister (Section 56 of the OPGGS Act).

3.1.2 EPBC Act 1999

The EPBC Act and supporting regulations provide for the protection of the environment and conservation of biodiversity in Australia (including Australian waters), particularly MNES. The EPBC Act is administered by the Department of the Environment and Energy (DoEE).

Amendments to the OPGGS Act and OPGGS (E) Regulations in February 2014, undertaken as part of the Commonwealth streamlining environmental approvals process, require MNES to be addressed in assessments of offshore petroleum development approvals. Therefore, the OPP process under the OPGGS (E) Regulations supersedes the Commonwealth referral process under the EPBC Act and replaces the requirement to prepare environmental approvals for submission to DoEE for petroleum development activities in Commonwealth waters.

This OPP covers the EPBC Act approval for those components of the project in Commonwealth waters.

The MNES relevant to the project are discussed in **Section 5.5.1**.

3.1.3 Other relevant Commonwealth legislation

Other Commonwealth legislation that is applicable to aspects of environmental management of the project is outlined in **Table 3-1**.

Table 3-1: Other relevant Commonwealth legislation

Legislation	Governing department	Summary	Relevance to project
Environment Protection (Sea Dumping) Act 1981	DoEE	This Act regulates permitted sea dumping and under the 1996 Protocol to the London Convention. Australia is required to minimise its waste disposal into the environment.	The project operations may result in release of wastes into the sea. ConocoPhillips recognises the importance of minimising waste disposal to the marine environment and will adhere to the requirements of this Act.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994	Australian Maritime Safety Authority (AMSA)	This Act relates to the protection of the sea from pollution by oil and other harmful substances discharged from ships. This Act disallows any harmful discharge of sewage, oil and noxious substances into the sea and sets the requirements for a shipboard waste management plan.	The project will adhere to the requirements of this Act as relevant to the project, including the following vessel requirements (as appropriate to vessel class): • Shipboard Oil Pollution Emergency Plan (SOPEP) • compliance with requirements for discharges and waste management, as outlined in the International Convention for the Prevention of Pollution from Ships (MARPOL) and Marine Orders (as appropriate to vessel class).

Legislation	Governing department	Summary	Relevance to project
Navigation Act 2012	Department of Infrastructure and Transport	The Act regulates international ship and seafarer safety, shipping aspects of protecting the marine environment and the actions of seafarers in Australian waters. It gives effect to the relevant international conventions relating to maritime issues to which Australia is a signatory, such as the International Convention for the Prevention of Pollution from Ships (MARPOL). The Act also has subordinate legislation contained in Regulations and Marine Orders.	The project will adhere to MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act.
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 and Regulations 1995	DoEE	The Act regulates emissions of ozone depleting substances (ODSs) and synthetic greenhouse gases (SGGs). It controls the manufacture, import and export of ODSs and SGGs and products containing these gases.	The project will adhere to restrictions on import and use of ODSs through implementing appropriate measures that control procuring of materials for operating and maintaining refrigeration and air conditioning equipment.
National Greenhouse and Energy Reporting Act 2007 National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015	DoEE, Clean Energy Regulator	The Act provides a single national framework for the reporting and dissemination of information related to greenhouse gas emissions, greenhouse gas projects, energy production and energy consumption, and for other purposes.	The project will adhere to the requirements for annual submission of a greenhouse and energy report in accordance with the Act. The Safeguard Mechanism will be applied to development projects constructed after 1 July 2020, where there will be a requirement to set a baseline for greenhouse gas (GHG) emissions using benchmarking. The Safeguard Mechanism aims to maintain emissions in line with a designated baseline via direct action or through the use of carbon credit instruments.

Legislation	Governing department	Summary	Relevance to project
Biosecurity Act 2015	Department of Agriculture and Water Resources	The Act relates to the management of diseases and pests that may cause harm to human, animal or plant health or the environment. The Act includes provisions for ballast water management plans and certificates, record-keeping obligations and powers to ensure compliance.	The project will comply with biosecurity requirements, specifically in relation to biofouling and ballast water requirements for vessels, offshore facilities and associated in-water equipment.
Australian Heritage Council Act 2003	DoEE	This Act identifies areas of heritage value, including those listed on the World Heritage List, National Heritage List and the Commonwealth Heritage List. The Act also establishes the Australian Heritage Council and its functions.	The project will take into any consideration heritage values (see **Section 5.7** for further discussion).
Historic Shipwrecks Act 1976 and Historic Shipwrecks Regulations 1978	DoEE	This Act protects shipwrecks that have lain in territorial waters for 75 years or more. It is an offence to interfere with any shipwreck covered by the Act.	Planned project operations will not interfere with any historical shipwrecks (see **Section 5.7.11** for further discussion).
National Environment Protection Council Act 1994	DoEE	This Act establishes the National Environment Protection Council (NEPC) that sets National Environment Protection Measures (NEPMS) to ensure that Australians have equivalent protection from air, water, soil and noise pollution. This Act is mirrored in all States and Territories.	The project will comply with requirements of the NEPC and minimise pollution wherever possible.

Legislation	Governing department	Summary	Relevance to project
National Environment Protection (National Pollutant Inventory) Measure 1998 (established under the *National Environment Protection Council Act 1994*)	DoEE	This measure provides the framework for the development and establishment of the National Pollutant Inventory (NPI), which provides publicly available information on the types, and amounts of certain substances, being emitted to the air, land, and water. Implementation of the NPI NEPM is the responsibility of each participating jurisdiction. State and territory environment protection agencies have their own legislative frameworks to ensure there is compliance with the NEPM.	The project will comply with the NPI NEPM through the reporting of relevant NPI substances.
National Environment Protection Measures (Implementation) Act 1998	DoEE	This Act provides for the implementation of NEPMs for certain activities carried on by or on behalf of the Commonwealth and Commonwealth authorities, and for related purposes.	The project will comply with the NEPMs where applicable.
Hazardous Waste (Regulation of Exports and Imports) Act 1989	DoEE	This Act regulates the export and import of hazardous waste to ensure that hazardous waste is disposed of safely so that human beings and the environment, both within and outside Australia, are protected from the harmful effects of the waste.	The project will comply with the export and import requirements for hazardous waste.
Telecommunications Act 1997	Department of Communications and the Arts	This Act regulates telecommunications in Australia, including the activities of telecommunication carriers and carriage service providers.	Secondary approvals required for the fibre optic cable will consider the requirements of this Act.

3.1.4 Australian Industry Participation legislation

In the context of the project, the Australian Industry Participation program is relevant, to encourage full, fair and reasonable opportunity for Australian industry to compete for work in major public and private projects in Australia. While not directly relevant to environmental management, it is included in this section for completeness.

The Australian Industry Participation National Framework encourages a consistent national approach to maximise Australian industry participation in major projects. Each jurisdiction has its own policies aimed at encouraging Australian industry participation in public and private projects.

The *Australian Jobs Act 2013* details Australian industry participation requirements for major projects valued at A$500 million or more. The Act ensures that information about opportunities to bid for work on major projects is provided by all levels of the project's supply chain.

In accordance with the Act, ConocoPhillips will prepare an Australian Industry Participation Plan detailing how all obligations will be met. The Australian Industry Participation Plan will be assessed by the Australian Industry Participation Authority.

3.2 Northern Territory legislation

The physical infrastructure and associated planned operations from the project are located within Commonwealth waters. However, there are some activities, for example vessels transiting to the offshore project area and those associated with unplanned events, that have potential to interact with values and sensitivities, such as species of conservation significance and coastlines that are within the jurisdiction of NT legislation (refer to **Section 5.5.6** for a description of sensitivities along the NT mainland coastline). **Appendix A (Table A-1)** outlines the principal NT legislation that may be applicable to the project at both a broad level and as specific to any spill response operations that may be required in NT waters.

The Commonwealth is currently working with the NT Government to further streamline offshore petroleum approval processes in their coastal waters. If enacted, this process may lead to future legislative amendments to confer the powers and functions for occupational health and safety, structural integrity and environmental management on NOPSEMA for offshore petroleum operations in designated coastal waters. While this does not influence the scope of this OPP in Commonwealth waters, any future planning will take into account legislative arrangements between the NT and the Commonwealth Governments at the time.

ConocoPhillips will adhere to NT legislation and prepare and submit the required approvals in accordance with relevant requirements at the time.

3.3 International agreements and conventions

Australia is signatory to various international treaties that have atmospheric and marine environment protection aspects. A number of these treaties are specifically designed to protect MNES, including:

- Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)
- International Convention on Wetlands of International Importance (Ramsar)
- Agreement Between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and Their Environment 1974 (commonly referred to as JAMBA)
- Agreement Between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and Their Environment 1986 (commonly referred to as CAMBA)
- Agreement Between the Government of Australia and the Government of the Republic of Korea for the Protection of Migratory Birds and Their Environment 2002 (commonly referred to as ROKAMBA).

The project is required to comply with the relevant requirements of each treaty. The key international environmental treaties and agreements that will apply to the project are detailed in **Appendix A (Table A-2)**.

3.4 Guidelines and codes of practice

Applicable guidelines and codes of practice for the project are summarised in **Appendix A (Table A-3)**.

3.5 EPBC management plans

3.5.1 Listed threatened species management/recovery plans and conservation advices

While it is considered highly unlikely that the project will have a significant impact on listed threatened species (refer to **Section 6**), the requirements of the relevant species management/recovery plans and conservation advices have been considered to identify any requirements that may be applicable. Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advices provide guidance on immediate recovery and threat abatement activities that can be undertaken to facilitate the conservation of a listed species or ecological community.

Table 3-2 outlines the management/recovery plans and conservation advices relevant to those species identified as potentially occurring or having habitat within the Barossa offshore development area, the gas export pipeline (collectively referred to as 'the project area') and area of influence (i.e. the existing environment that may be affected from unplanned activities; **Section 5.1**). The table also summarises the key threats to those species, as described in relevant management/recovery plans and conservation advices.

The management/recovery plans and conservation advices have been taken into consideration in assessing the impacts and risks associated with the project (**Section 6**) and will be further incorporated into implementation planning in activity-specific EPs.

Table 3-2: Summary of EPBC management/recovery plans and conservation advices relevant to the project

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Blue whale	Blue Whale Conservation Management Plan (October 2015) (DoE 2015a)	Noise interference	6.4.5
		Vessel disturbance	6.4.2
		Habitat modification including presence of oil and gas platforms/rigs, marine debris infrastructure and acute/chronic chemical discharge	6.4.2, 6.4.8, 6.4.9 and 6.4.10
		Whaling Climate variability and change	Not applicable – the key threats are outside the scope of this OPP
Humpback whale[1]	Humpback Whale Recovery Plan 2005-2010 (May 2005) (under review) (Department of Environment and Heritage (DEH) 2005a) Conservation advice (October 2015) (DoE 2015b)	Noise interference	6.4.5
		Entanglement - marine debris	6.4.9
		Vessel disturbance and strike	6.4.2
		Whaling Climate and oceanographic variability and change Overharvesting of prey Habitat degradation including coastal development and port expansion Entanglement – commercial fisheries or aquaculture equipment, and shark safety equipment	Not applicable – the key threats are outside the scope of this OPP

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Sei whale	Conservation advice (October 2015) (DoE 2015c)	Climate and oceanographic variability and change	Not applicable – the key threat is outside the scope of this OPP
		Anthropogenic noise and acoustic disturbance	6.4.5
		Habitat degradation including pollution (increasing port expansion and coastal development)	Not applicable – the key threat is outside the scope of this OPP
		Pollution (persistent toxic pollutants)	6.4.8 and 6.4.10
		Vessel strike	6.4.2
		Prey depletion due to fisheries (potential threat) Resumption of commercial whaling (potential threat)	Not applicable – the key threats are outside the scope of this OPP
Fin whale	Conservation advice (October 2015) (DoE 2015d)	Climate and oceanographic variability and change	Not applicable – the key threat is outside the scope of this OPP
		Anthropogenic noise and acoustic disturbance	6.4.5
		Habitat degradation including coastal development, increasing port expansion and aquaculture	Not applicable – the key threat is outside the scope of this OPP
		Pollution (persistent toxic pollutants)	6.4.8 and 6.4.10
		Fisheries catch, entanglement and bycatch	Not applicable – the key threat is outside the scope of this OPP
		Vessel strike	6.4.2
		Resource depletion due to fisheries (potential threat) Resumption of commercial whaling (potential threat)	Not applicable – the key threats are outside the scope of this OPP

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (June 2017) (DoEE 2017a) Conservation advice (December 2008) (Department of Environment, Water, Heritage and the Arts (DEWHA) 2008a)	Marine debris	6.4.9
		Light pollution	6.4.7
		Vessel disturbance	6.4.2
		Chemical and terrestrial discharge	6.4.8 and 6.4.10
		Habitat modification	6.4.2 and 6.4.3
		Noise interference	6.4.5
		Climate change and variability International take Terrestrial predation Fisheries bycatch Indigenous take Recreational activities Diseases and pathogens	Not applicable – the key threats are outside the scope of this OPP
Short-nosed sea snake[2] Leaf-scaled sea snake[2]	Conservation advice (December 2010) (DSEWPaC 2010a, b)	Degradation of reef habitat, primarily as a result of coral bleaching (principle threat)	Not applicable – the key threat is outside the scope of this OPP
		Oil and gas exploration	Not applicable – the EPBC Protected Matters search has not recorded the species within the project area. Consideration is given to this species in the context of habitat degradation from pollution associated with unplanned hydrocarbon spills (**Section 6.4.10**).
		Incidental catch and death in commercial prawn trawling fisheries (relevant to the NWMR) Unsustainable and illegal fishing practices (Ashmore Reef region)	Not applicable – the key threat is outside the scope of this OPP

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Curlew sandpiper Eastern curlew	Conservation advice (May 2015) (DoE 2015e, f) (notes that the threats are particularly relevant to eastern and southern Australia)	Ongoing human disturbance (in coastal areas and shoreline habitats) Habitat (intertidal mudflats) loss and degradation from pollution Changes to the water regime and invasive plants (in coastal areas and shoreline habitats)	Not applicable – the key threats are outside the scope of this OPP as they relate to disturbances in coastal areas and loss of intertidal mudflat habitat at key migration staging sites in the Yellow Sea. Consideration is given to these species in the context of habitat degradation from pollution associated with unplanned discharge of waste (**Section 6.4.9**) and unplanned hydrocarbon spills (**Section 6.4.10**).
Australian lesser noddy[2]	Conservation advice (October 2015) (DoE 2015g)	Habitat loss from catastrophic weather events	Not applicable – the key threat is outside the scope of this OPP
		Habitat loss from pollution[3]	6.4.9 and 6.4.10
		Overfishing Feral animals	Not applicable – the key threats are outside the scope of this OPP
Great knot[2]	Conservation advice (May 2016) (DoE 2016a)	Habitat loss and degradation (e.g. through land reclamation, industrial use and urban expansion, changes to the water regime, invasive plants, water quality deterioration and environmental pollution)	Not applicable – the EPBC Protected Matters search has not recorded the species within the project area. Some of the key threats are also outside the scope of this OPP. Consideration is given to this species in the context of habitat degradation from pollution associated with unplanned discharge of waste (**Section 6.4.9**) and unplanned hydrocarbon spills (**Section 6.4.10**).
		Pollution/contaminants[3]	6.4.9 and 6.4.10
		Disturbance (human-related, e.g. from recreational activities including fishing, boating, four-wheel driving, walking dogs, noise and night lighting[3])	These key threats are outside the scope of this OPP as they relate to disturbances from activities that are coastal related or are not directly relevant to the project.
		Climate change Diseases Direct mortality – hunting	Not applicable – the key threats are outside the scope of this OPP

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Greater sand plover[2] Lesser sand plover[2]	Conservation advice (May 2016 (DoE 2016b, c)	Habitat loss and degradation (e.g. loss of marine or estuarine vegetation, land clearing, intertidal reclamation, changes to the water/hydrological regime, changes in water quality, hydrology or structural changes near roosting sites, water pollution, and residential, farming, industrial and aquaculture/fishing activities)	Not applicable – the EPBC Protected Matters search has not recorded the species within the project area. Some of the key threats are also outside the scope of this OPP. Consideration is given to this species in the context of habitat degradation from water pollution associated with unplanned discharge of waste (**Section 6.4.9**) and unplanned hydrocarbon spills (**Section 6.4.10**).
		Pollution/contamination[3]	6.4.9 and 6.4.10
		Disturbance (human-related, e.g. from recreational activities including fishing, boating, four-wheel driving, walking dogs, noise and night lighting[3])	These key threats are outside the scope of this OPP as they relate to disturbances from activities that are coastal related or are not directly relevant to the project.
		Climate change Diseases	Not applicable – the key threats are outside the scope of this OPP
		Introduced species (invasion of intertidal mudflats by terrestrial weeds)	Not applicable – the key threat is outside the scope of this OPP as it relates to terrestrial pathways
		Direct mortality (e.g. from collision with large structures (e.g. wind farms) or vehicles/ aircraft, commercial hunting and predation)	Not applicable – the EPBC Protected Matters search has not recorded the species within the project area. The key threats are also outside the scope of this OPP.

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Western Alaskan bar-tailed godwit[2] Northern Siberian bar-tailed godwit[2]	Conservation advice (May 2016) (DoE 2016d, e)	Habitat loss and degradation (e.g. loss of marine or estuarine vegetation, changes to the water/hydrological regime, reduced river flows, intertidal reclamation, environmental pollution, industrial use and urban expansion)	Not applicable – the EPBC Protected Matters search has not recorded the species within the project area. The key threats are also predominantly outside the scope of this OPP. Consideration is given to this species in the context of habitat degradation from water pollution associated with unplanned discharge of waste (**Section 6.4.9**) and unplanned hydrocarbon spills (**Section 6.4.10**).
		Pollution/contamination[3]	6.4.9 and 6.4.10
		Disturbance (human-related, e.g. from recreational activities including fishing, boating, four-wheel driving, walking dogs, noise and night lighting[3])	These key threats are outside the scope of this OPP as they relate to disturbances from activities that are coastal related or are not directly relevant to the project.
		Climate change Diseases	Not applicable – the key threats are outside the scope of this OPP
		Introduced species (invasion of intertidal mudflats by terrestrial weeds)	Not applicable – the key threat is outside the scope of this OPP as it relates to terrestrial pathways
		Direct mortality (e.g. from collision with large structures (e.g. wind farms) or vehicles/ aircraft, commercial hunting and predation)	Not applicable – the EPBC Protected Matters search has not recorded the species within the project area. The key threats are also outside the scope of this OPP.

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Red knot[2]	Conservation advice (May 2016) (DoE 2016f)	Habitat loss and habitat degradation (e.g. through land reclamation, industrial use and urban expansion, changes to the water/hydrological regime, loss of marine or estuarine vegetation, invasive plants and environmental pollution of foraging and roosting sites)	Not applicable – the key threats are outside the scope of this OPP as they relate to disturbances to foraging/ roosting sites in coastal areas. Consideration is given to this species in the context of habitat degradation from pollution associated with unplanned discharge of waste (**Section 6.4.9**) and unplanned hydrocarbon spills (**Section 6.4.10**).
		Climate change Diseases	Not applicable – the key threats are outside the scope of this OPP
		Pollution/contamination	6.4.8, 6.4.9 and 6.4.10
		Disturbance (human-related, e.g. from recreational activities including fishing, boating, fourwheel driving, walking dogs, noise and night lighting)	These key threats are outside the scope of this OPP as they relate to disturbances from activities that are coastal related or are not directly relevant to the project. Consideration is given to this species in the context of disturbance from night lighting (**Section 6.4.7**).
		Direct mortality (e.g. wind farms, bird strike with vehicles and aircraft, hunting, chemical spills and oil spills)	These key threats are outside the scope of this OPP as they relate to disturbances from activities that are not directly relevant to the project. Consideration is given to this species in the context of disturbance from chemical/oil spills (**Section 6.4.10**).
Abbott's booby[2]	Conservation advice (October 2015) (DoE 2015h)	Loss of rainforest habitat Introduced terrestrial species (e.g. yellow crazy ant)	Not applicable – the key threats are outside the scope of this OPP

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Whale shark	Whale shark (*Rhincodon typus*) Recovery Plan (2005) (May 2005) (DEH 2005b) Conservation advice (October 2015) (DoE 2015i)	Pollution and marine debris	6.4.9 and 6.4.10
		Vessel strike	6.4.2
		Habitat disruption from mineral exploration, production and transportation	6.4.2
		Intentional/unintentional mortality from fishing outside of Australian waters (principle threat) Climate change Disturbance from tourism operations	Not applicable – the key threats are outside the scope of this OPP
Great white shark[1]	Recovery Plan for the White Shark (*Carcharodon carcharias*) (August 2013) (DSEWPaC 2013a)	Accidental (bycatch) or illegal (targeted) capture by commercial and recreational fisheries (including issues of post release mortality) Shark control activities (e.g. beach meshing or drum lining) (note, this threat is particularly relevant to the east coast population) Illegal trade Climate change Ecotourism	Not applicable – the key threats are outside the scope of this OPP
		Habitat modification/ degradation (e.g. development, pollution) (note, coastal habitat degradation and anthropogenic activities in near-coast areas are of primary relevance as they are often a preferred habitat)	6.4.2, 6.4.8, 6.4.9 and 6.4.10

Species	Recovery plan/ conservation advice (date adopted)	Key threats identified in the recovery plan and conservation advice	OPP risk assessment section
Grey nurse shark[4]	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (August 2014) (DoE 2014a)	Incidental (accidental and/or illegal) capture by commercial and recreational fishers Shark control activities (e.g. beach meshing or drum lining) Ecotourism Collection for public aquaria Disease Climate change	Not applicable – the key threats are outside the scope of this OPP
		Pollution	6.4.8, 6.4.9 and 6.4.10
		Habitat modification/ degradation (e.g. through coastal development, pollution)	6.4.2 Pollution, in a general sense, is addressed in **Section 6.4.7** to **Section 6.4.9**, as outlined above.
Speartooth shark Northern river shark Green sawfish Largetooth sawfish Dwarf sawfish	Sawfish and River Sharks Multispecies Recovery Plan (November 2015) (DoE 2015j) Conservation advice: speartooth shark (April 2014) (DoE 2014b), northern river shark (April 2014) (DoE 2014c), dwarf sawfish (October 2009) (DEWHA 2009) and green sawfish (2008) (DEWHA 2008b)	Fishing activities including being caught as by-catch and illegal, unreported and unregulated fishing (principle threat)	Not applicable – the key threat is outside the scope of this OPP
		Habitat degradation and modification (note, the recovery plan focuses on river and estuarine barriers that affect the migration of river sharks/sawfish)	6.4.2, 6.4.8, 6.4.9, 6.4.10
		Marine debris (potential threat)	6.4.9
		Collection for display in public aquaria (potential threat)	Not applicable – the key threat is outside the scope of this OPP

1 Although the species were identified in the EPBC Protected Matters search they are highly unlikely to occur in the project area, which is outside the species range or preferred habitat (see **Section 5.6.2** for humpback whales and **Section 5.6.6** for great white sharks). However, the species may occur within the area of influence.

2 These species were identified only in the area of influence EPBC Protected Matters search.

3 Potential pollution associated with planned discharges or light emissions from the project are not relevant as the EPBC Protected Matters search did not record the species as potentially occurring or having habitat within the project area (refer to **Table 5-4**).

4 The species was not identified in the EPBC Protected Matters search but was observed during the Barossa marine studies program at a seamount within the broader vicinity of the Barossa offshore development area (**Section 5.6.3**). Therefore, a conservative approach has been applied and it is considered the species may pass through the area.

3.5.2 Australian Marine Parks

Australian Marine Parks (AMPs, previously known as Commonwealth Marine Reserves) are recognised under the EPBC Act for the purpose of protecting and maintaining biological diversity, and to contribute to a national representative network of marine protected areas.

Current management arrangements

Once a marine park is proclaimed, Parks Australia develops a management plan for the park which details how the park is to be managed, including what activities are allowed in the different zones of the park. For those marine parks proclaimed before 2012, current management arrangements apply (even if the previous management plan has now expired). For marine parks proclaimed after 2012, transitional management arrangements are currently in place and will apply until statutory management plans come into effect. Until the management plans come into effect, activities within marine parks proclaimed after 2012 are still required to be consistent with the Australian International Union for Conservation of Nature (IUCN) reserve management principles (Environment Australia 2002), as relevant to the IUCN category assigned to the AMP. The IUCN management principles and categories have been given legal effect in relation to AMPs in the EPBC Act.

A number of marine parks have been considered in relation to the project. A portion of the gas export pipeline corridor intersects the Oceanic Shoals marine park, which is entirely zoned as Multiple Use Zone (IUCN category VI) (**Figure 3-2a**). In addition, the area of influence also overlaps the Arafura, Arnhem, Kimberley, Ashmore Reef and Cartier Island AMPs. Each of these have various management zones and the Australian IUCN reserve management principles, as defined by Environment Australia (2002), related to the zones that are relevant to the project, are provided in **Table 3-3**. Further contextual description of the area of influence is provided in **Section 5.1** of this OPP.

Table 3-3: IUCN reserve management principles for the Australian Marine Parks relevant to the project

AMP	IUCN category	Australian IUCN reserve management principles
Oceanic Shoals	Category VI (Multiple Use Zone)	• 7.01 The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. • 7.02 The biological diversity and other natural values of the reserve • 7.03 Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. • 7.04 Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles.
Arafura	Category VI (Multiple Use Zone)	
Arnhem	Category VI (Special Purpose Zone)	
Kimberley	Category VI (Multiple Use Zone)[1]	
Ashmore Reef	Category Ia (Sanctuary Zone/ Strict Nature Reserve) and Category II (Recreational Use Zone/National Park)[2]	*Category Ia* • 1.01 The reserve or zone should be managed primarily for scientific research or environmental monitoring based on the following principles. • 1.02 Habitats, ecosystems and native species should be preserved in as undisturbed a state as possible. • 1.03 Genetic resources should be maintained in a dynamic and evolutionary state. • 1.04 Established ecological processes should be maintained. • 1.05 Structural landscape features or rock exposures should be safeguarded. • 1.06 Examples of the natural environment should be secured for scientific studies, environmental monitoring and education, including baseline areas from which all avoidable access is excluded. • 1.07 Disturbance should be minimised by careful planning and execution of research and other approved activities. • 1.08 Public access should be limited to the extent it is consistent with these principles.

AMP	IUCN category	Australian IUCN reserve management principles
		Category II • 3.01 The reserve or zone should be protected and managed to preserve its natural condition according to the following principles. • 3.02 Natural and scenic areas of national and international significance should be protected for spiritual, scientific, educational, recreational or tourist purposes. • 3.03 Representative examples of physiographic regions, biotic communities, genetic resources, and native species should be perpetuated in as natural a state as possible to provide ecological stability and diversity. • 3.04 Visitor use should be managed for inspirational, educational, cultural and recreational purposes at a level that will maintain the reserve or zone in a natural or near natural state. • 3.05 Management should seek to ensure that exploitation or occupation inconsistent with these principles does not occur. • 3.06 Respect should be maintained for the ecological, geomorphologic, sacred and aesthetic attributes for which the reserve or zone was assigned to this category. • 3.07 The needs of indigenous people should be taken into account, including subsistence resource use, to the extent that they do not conflict with these principles. • 3.08 The aspirations of traditional owners of land within the reserve or zone, their continuing land management practices, the protection and maintenance of cultural heritage and the benefit the traditional owners derive from enterprises, established in the reserve or zone, consistent with these principles should be recognised and taken into account.
Cartier Island	Category Ia (Sanctuary Zone)[2]	• 1.01 The reserve or zone should be managed primarily for scientific research or environmental monitoring based on the following principles. • 1.02 Habitats, ecosystems and native species should be preserved in as undisturbed a state as possible. • 1.03 Genetic resources should be maintained in a dynamic and evolutionary state. • 1.04 Established ecological processes should be maintained. • 1.05 Structural landscape features or rock exposures should be safeguarded. • 1.06 Examples of the natural environment should be secured for scientific studies, environmental monitoring and education, including baseline areas from which all avoidable access is excluded. • 1.07 Disturbance should be minimised by careful planning and execution of research and other approved activities. • 1.08 Public access should be limited to the extent it is consistent with these principles.

[1] Describes the zoning as relevant to that which is intersected by the area of influence for the project.

[2] The zoning aligns with the Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve Management Plans 2002 (expired in 2009).

Proposed management arrangements

In September 2014, the Australian Government commissioned an independent review of the AMPs network to consider what management arrangements would best protect the marine environment and accommodate the many activities that occur within it. The independent review was undertaken by an Expert Scientific Panel and a Bioregional Advisory Panel and was completed in December 2015, with the reports made publicly available in September 2016. Following that, the Director of National Parks commenced the statutory process for developing new reserve management plans.

In July 2017, the Director of National Parks published, for public comment, draft management plans which detailed the approach to manage 44 AMPs. The plans were developed in accordance with the EPBC Act. The zoning and related rules for managing activities in the AMPs took into consideration the best available science, the advice of stakeholders, Indigenous people and the general public, the goals and principles of the National Representative System of Marine Protected Areas, and the Australian IUCN reserve management principles (Environment Australia 2002; Director of National Parks 2017a, b).

The draft management plans for the North and North west marine parks are of relevance to the project and were reviewed. The Draft North Commonwealth Marine Reserves Network Management Plan[3] proposes revising the zoning of areas within the Oceanic Shoals marine park, which is currently entirely zoned as Multiple Use Zone (IUCN category VI) (**Figure 3-2a**). As shown in **Figure 3-2b**, the revised zoning includes designating portions of the Oceanic Shoals marine park as a Special Use Zone, a Marine National Park Zone and a Habitat Protection Zone. Specifically, the Habitat Protection Zone has been provided with the intention of improving protection to the benthic ecosystems of the carbonate banks and terraces of the Van Diemen Rise (Buxton and Cochrane 2015). While the Barossa offshore development area is outside the boundaries of any existing or known proposed AMPs, the gas export pipeline corridor overlaps a portion of the currently zoned Multiple Use Zone (IUCN category VI) and proposed Habitat Protection Zone (IUCN category IV) shown in **Figure 3-2**.

As stated previously, until these draft management plans come into effect, current management arrangements continue to apply and there are no changes 'on the water' for users in the AMPs.

3.6 Perth Treaty

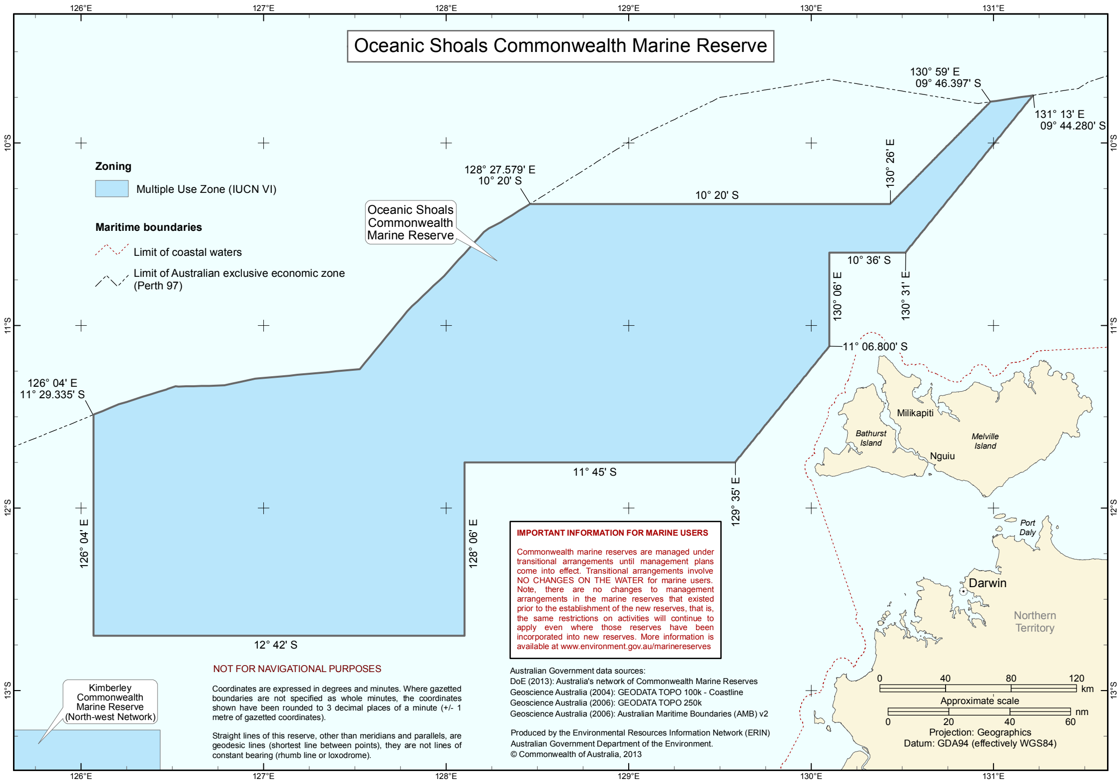
Australia and Indonesia have entered into a number of agreements and arrangements relating to the maritime area between Australia and Indonesia, including the *Treaty between the Government of Australia and the Government of the Republic of Indonesia establishing an Exclusive Economic Zone Boundary and Certain Seabed Boundaries* (the 1997 Perth Treaty). Under the Perth Treaty, there are areas of overlapping jurisdiction where Australia exercises seabed jurisdiction including for petroleum exploration, and Indonesia exercises water column jurisdiction including fishing rights (the Perth Treaty area). The Perth Treaty boundary is contiguous with the Australian Exclusive Economic Zone (EEZ) boundary in the Timor and Arafura Seas.

While the Perth Treaty has yet to be officially sanctioned by the Australian and Indonesian governments, the Australian Government acts consistently with its obligations.

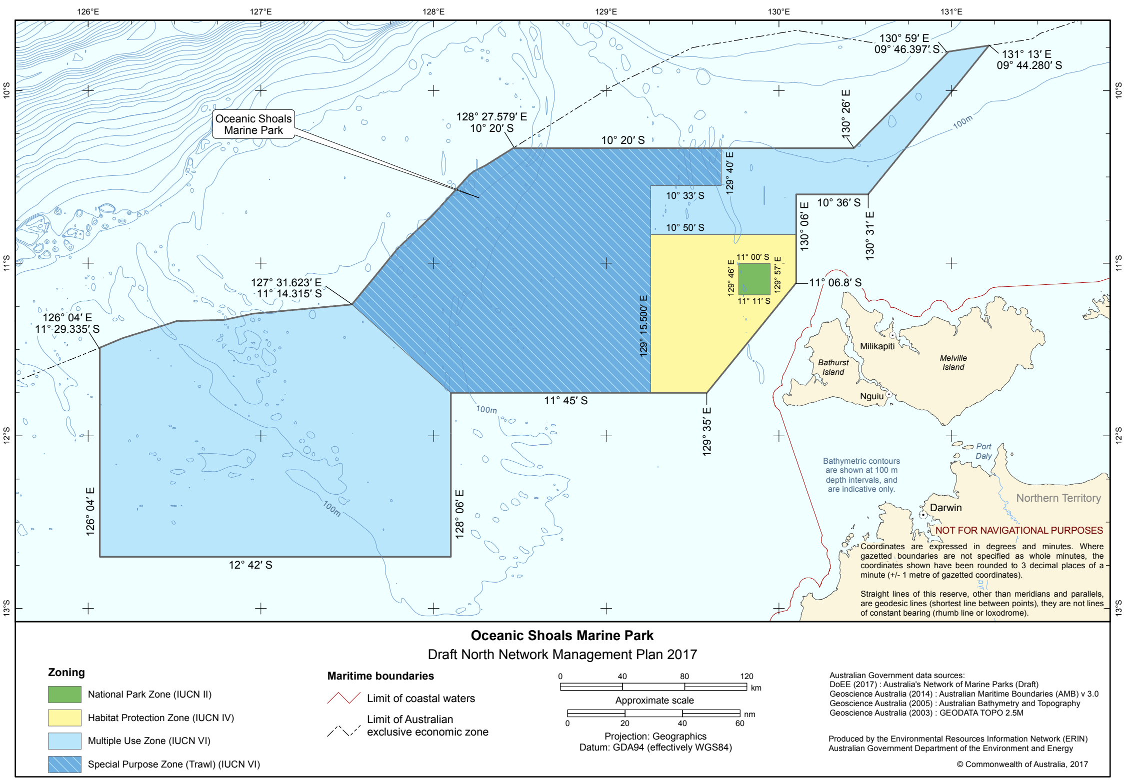
The portion of the Barossa offshore development area that is located between the Perth Treaty boundary and the 1972 continental shelf boundary is in an area of overlapping jurisdiction (**Figure 4-2**). Under the Perth Treaty, within this area of overlapping jurisdiction Indonesia may exercise EEZ sovereign rights and jurisdiction in relation to the water column (Article 7), whereas Australia may exercise continental shelf sovereign rights and jurisdiction in relation to the seabed. From a fisheries jurisdiction and management perspective this means that Indonesia has rights to pelagic fish stocks in this area of overlapping jurisdiction, whereas Australia has rights to the demersal and benthic fish stocks. The demarcation between pelagic and demersal fish is not clear, as the wording used in the *Memorandum of Understanding Between the Government of the Republic of Indonesia and the Government of Australia Concerning the Implementation of a Provisional Fisheries Surveillance and Enforcement Arrangement* (1981) is "swimming fish species" and "sedentary fish species".

Article 7 of the Perth Treaty requires that Australia give Indonesia three months' notice of proposed grant of exploration and exploitation rights in the Perth Treaty area. The notification process is conducted by the Australian Government Department of Industry, Innovation and Science (DIIS) through the Attorney-General's Department and the Department of Foreign Affairs and Trade (DFAT), which liaise directly with the Indonesian Government in Jakarta. ConocoPhillips will liaise with DIIS and DFAT as the project progresses to allow timely communication and engagement with Indonesia should any project activities be required in this area.

3 The draft management plans were released prior to the formal name change from Commonwealth Marine Reserves to Australian Marine Parks, which occurred on the 11 October 2017. The final management plans will be amended to reflect the revised naming.



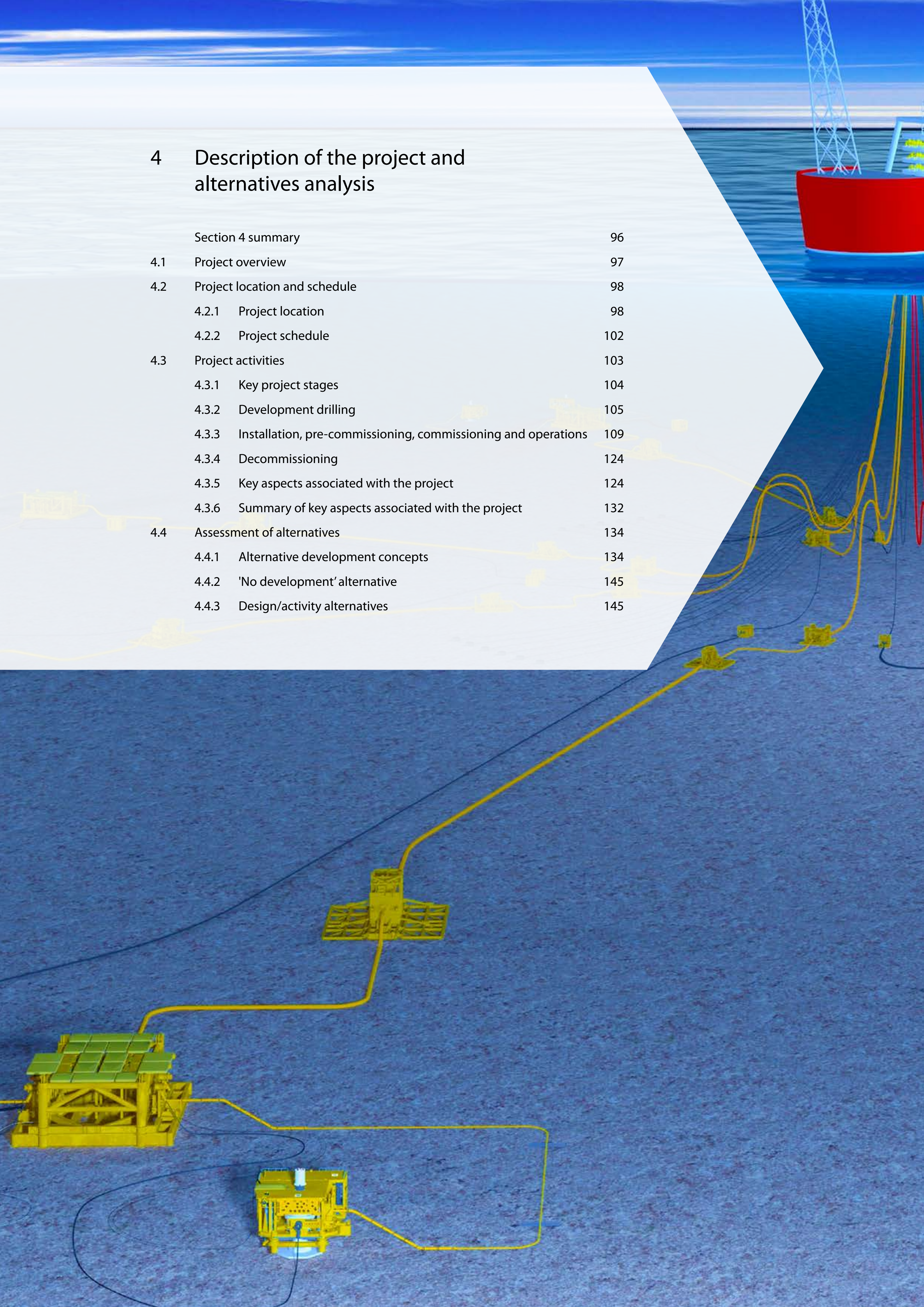
a) Current zoning under transitional arrangements



b) Proposed zoning detailed in the draft management plan

Figure 3-2: Oceanic Shoals marine park current zoning and proposed zoning as detailed in the draft management plan

4 Description of the project and alternatives analysis



Section 4 summary

Purpose:

This section describes the development concept that forms part of the proposal and which will be subject to further engineering design before the final concept is detailed in activity-specific Environment Plans. Discussion of alternatives, including the types of facilities that were considered and not carried forward, is also presented with a focus on the environmental impacts and risks involved.

The typical stages of an offshore project's development and the relevant activities within each stage are also described.

Section at a glance:

Project overview: The project is a gas and light condensate project that proposes to provide a new source of dry gas to the existing DLNG plant for approximately 25 years. Project facilities will comprise a Floating Production Storage and Offloading (FPSO) facility, subsea production system, supporting in-field infrastructure and gas export pipeline. The FPSO facility will store and offload condensate to a separate vessel for export and will treat and export dry gas through a new pipeline that is proposed to tie into the existing Bayu-Undan to Darwin pipeline in Commonwealth waters. Environmental baseline studies completed as part of the Barossa marine studies program informed this design concept.

Project location and schedule: The Barossa offshore development area is in Commonwealth waters, approximately 300 km north of Darwin, 227 km north of the NT coastline and 100 km north of the Tiwi Islands at its closest point. The new pipeline that will transport the dry gas from the Barossa offshore development area will be approximately 260 km–290 km long and could pass approximately 6 km west of the Tiwi Islands at its closest point. While appropriate commercial arrangements are yet to be put in place, it is proposed to connect to the existing Bayu-Undan to Darwin pipeline in Commonwealth waters.

Assuming all the required approvals are in place, offshore development work, starting with the drilling of development wells, will start around 2019. During this period, the FPSO facility will be built and then towed to the development area and other subsea infrastructure and the gas export pipeline will also be installed.

After a commissioning stage where all the systems are tested, operations will start in about 2023. The total number of wells drilled is anticipated to be in the order of 10–25. Decommissioning of the project will occur at the end of the field life and requires a separate EP before it can occur. Decommissioning is expected to occur from about 2043.

Project activities: A description of the key characteristics of the project is provided including the proposed wells and drilling methods, the FPSO facility, subsea production system, supporting in-field infrastructure, the gas export pipeline, fibre optic cable and the potential for the project to include future development of the Caldita Field. As the exact route of the pipeline is not final and subject to further studies, the impacts and risks of laying the pipeline within a broader corridor have been assessed. The new pipeline and associated installation activities will occur within that corridor.

Assessment of alternatives: A number of development concepts including an FPSO, an offshore fixed jacket platform, a floating LNG facility and 'no development' option were considered. Assessment of the different concepts involved consideration of a number of factors including environmental acceptability, technical feasibility, safety, commercial viability and ConocoPhillips' objectives for sustainable and environmentally responsible development.

Two of these concepts, an FPSO facility and an offshore fixed jacket facility, were selected for further assessment and subjected to a rigorous and detailed evaluation. The evaluation concluded that an FPSO facility will be safer, more environmentally acceptable and will make the eventual decommissioning of the field easier. The FPSO concept also has lower capital expenditure cost, increasing the commercial viability of the project which increases the likelihood of securing the capital funding necessary to develop the project and capture the benefits associated with development. This section also contains a description of some design and activity alternatives still under consideration.

Key aspects associated with the project: Key aspects of the project (as relevant to the environment) described include physical presence, vessel movements, seabed disturbance, underwater noise emissions, biosecurity (invasive marine species), atmospheric emissions, light emissions, waste management and planned and unplanned discharges.

4 Description of the project and alternatives analysis

This section of the OPP provides a comprehensive description of the key project stages and activities (based on current engineering definition and subject to the required commercial arrangements being put in place) as relevant to the assessment of environmental impacts and risks, such as the key discharge and emission sources. It defines the nature and scale of the project and has informed an appropriate description of the existing marine environment (**Section 5**). Understanding both the project and the existing marine environment allows the sources of impacts and risks to be appropriately evaluated (**Section 6**).

This section aligns with OPGGS Regulation 5A (5(b) and f) and the NOPSEMA OPP Guidance Note (NOPSEMA 2016a): *"To provide information important to the context of the OPP by identifying and describing all its component activities at an appropriate level of detail and particularly those activities relevant to environmental impact and risk"*. It only addresses those aspects of the project that will occur in Commonwealth waters.

4.1 Project overview

The proposed development concept for the project comprises an FPSO facility, subsea production system, supporting in-field subsea infrastructure, and gas export pipeline (**Figure 4-1**). The FPSO facility will be the central processing facility to stabilise, store and offload condensate, and to treat, condition and export gas. The condensate will be periodically transported to market from the Barossa offshore development area by export tankers. The FPSO facility will be permanently moored and remain in the Barossa offshore development area for the life of the project. The FPSO facility will also accommodate offshore personnel.

The extracted dry gas will be exported from the FPSO facility through a gas export pipeline that will tie into the existing Bayu-Undan to Darwin gas export pipeline in Commonwealth waters (**Figure 1-1**), which then transports the dry gas to the DLNG facility (subject to appropriate commercial arrangements being put in place). The new gas export pipeline will be notionally in the order of 260 km–290 km, depending on the route selected and tie-in location into the existing Bayu-Undan to Darwin gas export pipeline.

The design of the development concept has been informed and influenced by data and information derived from the comprehensive environmental baseline studies completed as part of the Barossa marine studies program, and supplemented by published literature (**Section 5**). At this preliminary engineering stage, some design/activity alternatives are still being evaluated, such as the final location of the FPSO facility, type and configuration of in-field subsea infrastructure, the gas export pipeline route within the defined corridor, and the location of the export pipeline tie-in to the Bayu-Undan to Darwin gas export pipeline. It is necessary to include these alternatives at this stage of the project as further detailed engineering is needed to finalise the development concept. Detailed engineering will occur following acceptance of the OPP, aligned with ConocoPhillips' project phases (**Figure 3-1**). Impact and risk assessments undertaken for this OPP have considered all reasonable design/activity alternatives, in order to fully evaluate the environmental acceptability of the project. Evaluation and comparison of environmental impacts and risks for key design/activity alternatives is discussed in **Section 4.4**.

Key considerations in the design of the project include:

- ensuring the health and safety of personnel working on the project through its full design life
- minimising negative impacts the project may have on environmental, social and heritage values and sensitivities
- providing a reliable supply of gas and condensate to market through the most appropriate route to market, with particular consideration for continued use of existing infrastructure (Bayu-Undan to Darwin gas export pipeline and DLNG facility) and socio-economic benefits to the Darwin community.

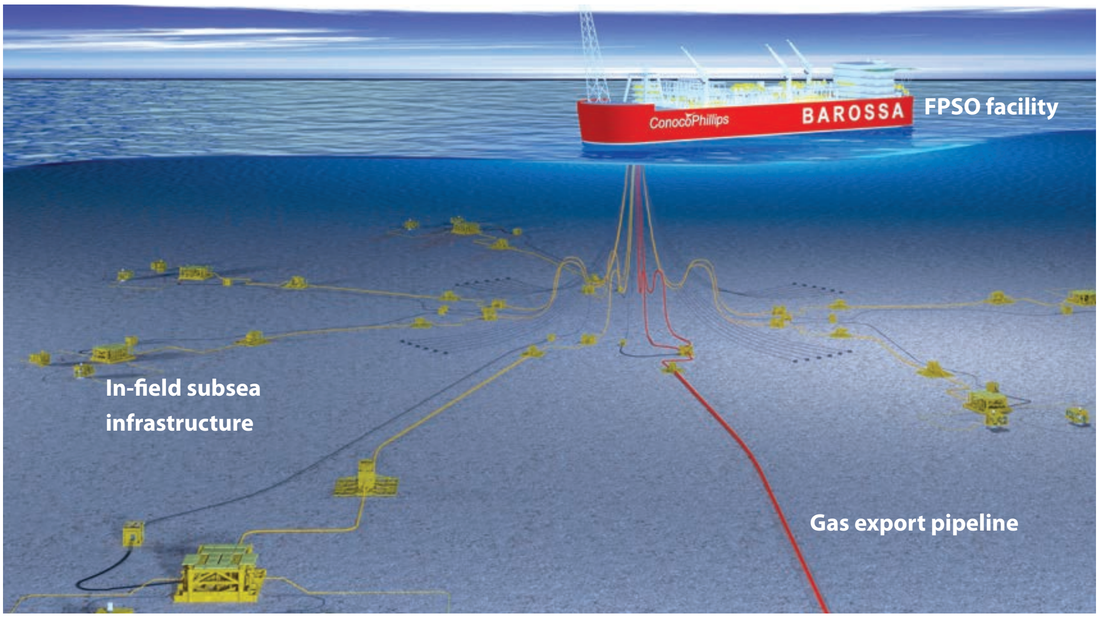


Figure 4-1: Indicative schematic of the FPSO facility development concept

4.2 Project location and schedule

4.2.1 Project location

The Barossa offshore development area is located in Commonwealth waters, approximately 227 km north of the NT coastline and 100 km north of the Tiwi Islands at its closest point (**Figure 1-1**), with water depths ranging between 130 m and 350 m.

The gas export pipeline corridor is located in Commonwealth waters and is approximately 6 km west of the Tiwi Islands at its closest point (**Figure 1-1**). Water depths within the pipeline corridor range from approximately 30 m to 240 m deep, with the exception of a shallow water area (approximately 30 km long) immediately east of the Oceanic Shoals marine park (**Figure 4-12**) where minimum water depths may be as shallow as approximately 5 metres. The gas export pipeline shall be routed within the corridor to reduce environmental impacts to local seabed features where practicable.

The closest major populated centre is Darwin, located approximately 300 km south of the Barossa offshore development area. The location of the Barossa offshore development area and the indicative location of the FPSO facility, which will be located within the Barossa Field, is presented in **Figure 4-2**.

4.2.1.1 Definition of project area

The Barossa offshore development area and gas export pipeline corridor define the geographic extent of the project area that is applicable for planned activities, which are considered and risk assessed in this OPP. For the purposes of this OPP, the extent of the Barossa offshore development area is considered to comprise the area outlined in **Figure 4-2**. The area encompasses ConocoPhillips' interests in the Bonaparte Basin (i.e. petroleum retention leases NT/RL5 and NT/RL6; herein referred to as the permit areas), the Barossa Field, Caldita Field, MODU/drill ship, FPSO facility, subsea production system, supporting in-field subsea infrastructure, and marine environment that may be affected by planned discharges (as identified from modelling, which is presented in (**Section 6.4.8**). The extent of the Barossa offshore development area (**Figure 4-2**) also accommodates the movement of project vessels in the vicinity of the FPSO facility and in-field subsea infrastructure. expected to be significantly smaller than the area shown in **Figure 4-2**, ConocoPhillips has taken a conservative approach and has defined a larger project area to inform the basis of the impact and risk assessment. Including a buffer also provides flexibility to account for the early design phase and potential future expansion of the project.

As the location of the gas export pipeline route is subject to further field survey and detailed engineering studies to inform selection of a route that mitigates the risks during installation and operation as far as practicable, a pipeline route corridor has been defined in which the physical footprint of the pipeline and project vessel installation or operations activities will occur (**Figure 4-3**). The entire corridor has been assessed in this OPP. As with the Barossa offshore development area, the area directly influenced by the gas export pipeline will be significantly smaller than the area shown in **Figure 4-3,** given the size and likely installation footprint of the pipeline.

The OPP considers the potential impacts and risks to the existing environment that may be affected from both planned (as mentioned above) and unplanned activities. The outer boundary of the existing environment that may be affected (i.e. the 'area of influence') has been defined using the most conservative extent of the adverse exposure zone (i.e. area within which impact may occur) for hydrocarbons from unplanned release scenarios relevant to the project. Refer to **Section 5.1** for further discussion on the definition of the area of influence.

This OPP does not include the transit of vessels to or from the Barossa offshore development area or to or from the gas export pipeline corridor. These activities will be undertaken in accordance with relevant maritime legislation – most notably, the Commonwealth *Navigation Act 2012* – and, therefore, fall within the jurisdiction of the AMSA. Therefore, activities undertaken by the vessels beyond the Barossa offshore development area or gas export pipeline corridor boundary are not considered in this OPP.

The OPP excludes the operation of onshore support facilities required during installation, commissioning and operation, as these will be assessed under relevant NT government planning and approvals processes.

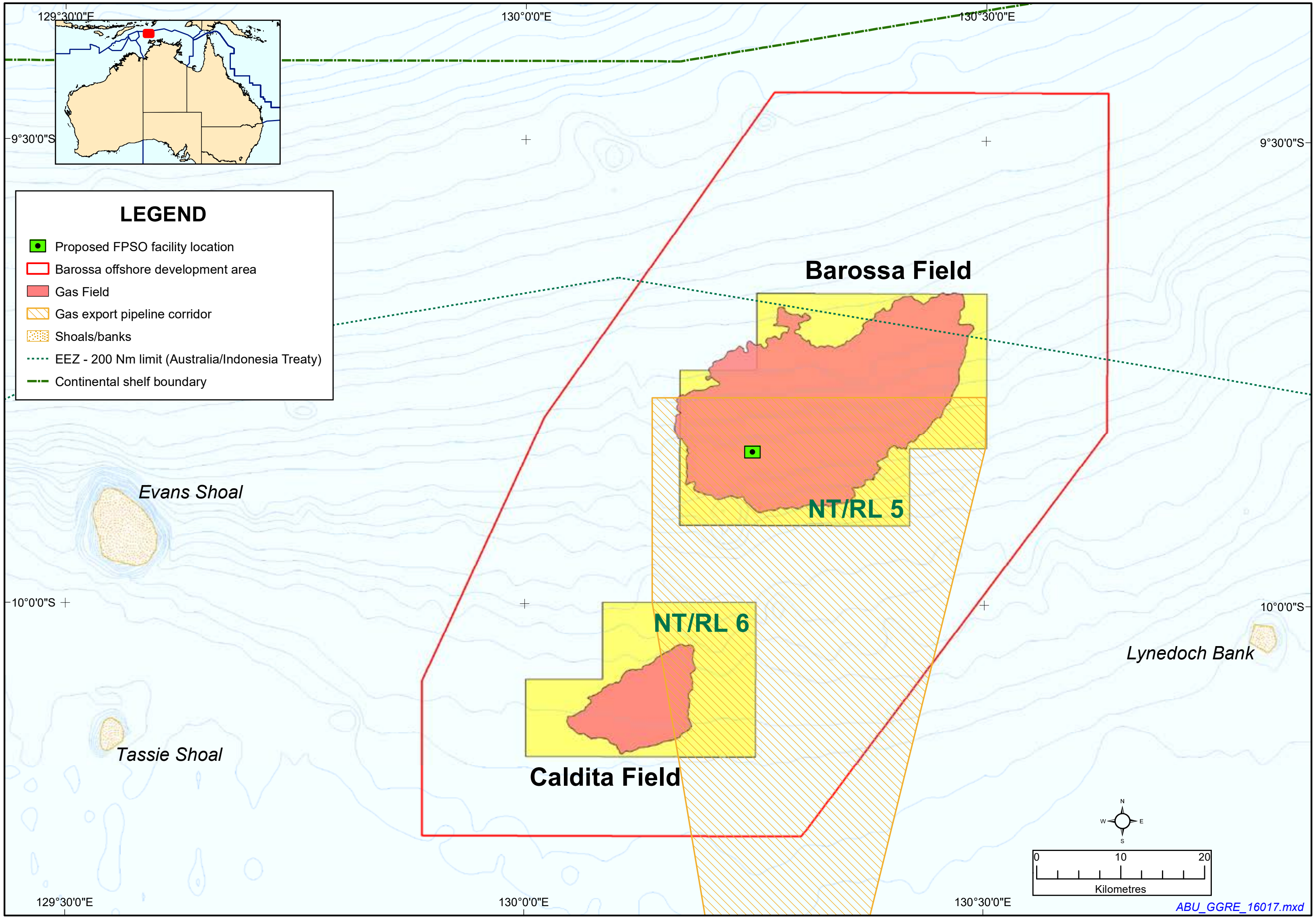


Figure 4-2: Barossa offshore development area location

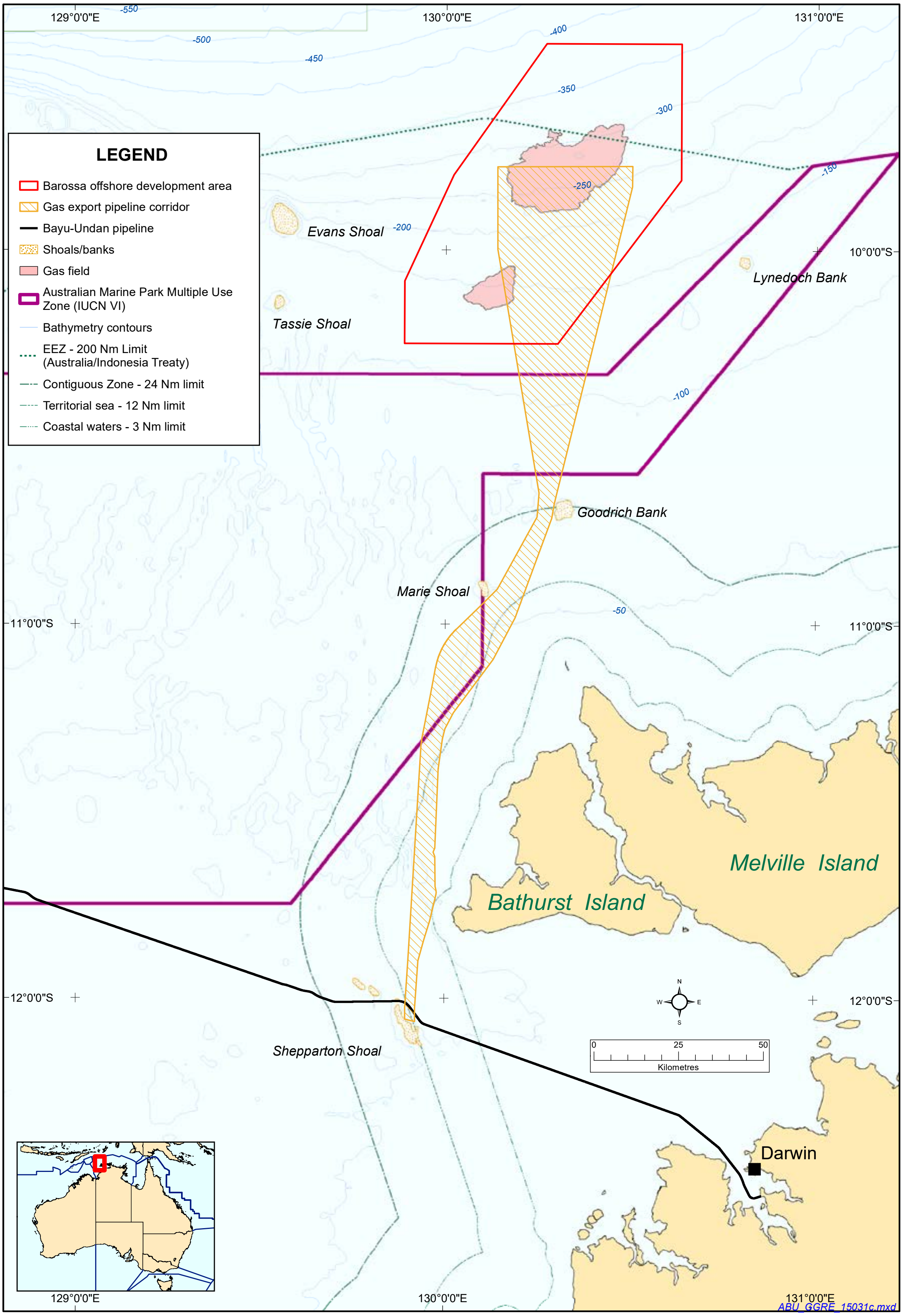


Figure 4-3: Gas export pipeline corridor

4.2.2 Project schedule

The pre-FEED work for the project, which aligns with the ConocoPhillips select phase, is currently underway and is anticipated to be followed by FEED in 2018 (**Figure 3-1**). The final investment decision as to whether to execute the project is anticipated to be made in 2019.

Following FID, it is anticipated it will take approximately four years for the purpose-built FPSO facility to be constructed, after which it will be towed to location. The development drilling program is expected to occur in multiple phases to reflect the staged development of the reservoir across the life of the project.

The life of the project is expected to be approximately 25 years from first gas, although this may vary based on field performance and economic conditions and commercial terms of access to existing infrastructure. The design life of the project facilities will be engineered to meet the expected life of the project.

The timeframes and development schedule of key project activities are presented in **Table 4-1**. The specific timing and schedule of the project activities will be influenced by commercial decisions, approvals, contracting, fabrication, vessel and equipment availability, and weather conditions.

Table 4-1: Project indicative timeframe

Project activity	Target date/timeframe
Development drilling	
Phase 1	Approximately 6 months–2 years post-FID
Phase 2	Approximately 4 years post first gas
Phase(s) 3(+)	During operations (this may include development of the Caldita Field if it is found to be economically viable)
Installation, pre-commissioning and commissioning	
Gas export pipeline installation (including gas export pipeline infrastructure and fibre optic cable)	Approximately 1–3 years post-FID
In-field subsea infrastructure installation	Approximately 2–4 years post-FID
Tow-out and hook up of the FPSO facility	Approximately 3–5 years post-FID
Commissioning	Approximately 4 years post-FID
Operations	
First gas	Approximately 4–5 years post-FID
Operations	Duration of approximately 25 years post first gas
Decommissioning	Approximately 25 years post first gas

4.3 Project activities

As per the requirements of Regulation 5A (5)(b) of the OPGGS (E) Regulations, the following subsections provide a comprehensive description of the project, including locations, operational details, and any additional information relevant for consideration of environmental impacts and risks associated with the project. A detailed assessment of the potential environmental impacts and risks related to the project activities is provided in **Section 6**.

The key characteristics of the project are summarised in **Table 4-2**. ConocoPhillips is targeting a production rate of approximately 3.7 Mtpa of LNG, and approximately 1.5 MMbbl/yr of condensate.

Table 4-2: Barossa project key characteristics

Project characteristic*	Description
Overview	
Basin	Bonaparte
Gas field	Barossa and Caldita
Location	Approximately 300 km north of Darwin
Anticipated hydrocarbon	Natural gas and condensate
Approximate LNG production rate	3.7 Mtpa (existing DLNG facility capacity)
Water depths (approximate)	Barossa offshore development area: 130 m–350 m Gas export pipeline corridor: ranging from approximately 30 m to 240 m deep, with the exception of a shallow water area (approximately 30 km long) immediately east of the Oceanic Shoals marine park where minimum water depths may be as shallow as approximately 5 m.
Proposed wells	Anticipated to be in the order of 10–25 subsea wells. Additional wells may be required following future near-field exploration campaigns but only inside the Barossa offshore development area. These will be drilled using similar techniques as outlined in this OPP (**Section 4.3.2**), and will be detailed in activity-specific EPs.
Operating life	Approximately 25 years
First gas	Target approximately 4-5 years post-FID
FPSO facility	FPSO facility in the Barossa offshore development area, which collects and processes raw well fluids, and prepares condensate for direct export by offtake tankers and treats dry gas for transport via a gas export pipeline to the DLNG facility.
In-field umbilicals	In-field umbilicals providing chemicals, power, control signals and monitoring signals will connect the subsea Christmas trees, wells and manifolds to the FPSO facility. Subsea umbilical distribution units may be used to distribute chemicals, power and signals to the various manifolds and subsea wells.
In-field subsea infrastructure	Manifolds, flowline end terminations, riser base structures connect flowlines, risers, spools and jumpers together.

Project characteristic*	Description
In-field flowlines	A production gathering system of flowlines and risers transfer reservoir fluids from the subsea wells to the FPSO facility. Other in-field flowlines may include water, gas and chemical lines. Smaller diameter flowlines or service lines may be used to assist with well start up and reservoir/production management.
Gas export pipeline	A single new gas export pipeline (in the order of approximately 260 km–290 km in length and 24–26 inches in diameter) will connect the FPSO facility to the existing Bayu-Undan to Darwin gas export pipeline within the defined corridor. Provision for connecting a subsea intelligent pig launcher (temporary installation only) will be provided at the FPSO facility end of the gas export pipeline (see **Section 4.3.3.2** for further detail). Provision for connecting a subsea intelligent pig receiver, for local receipt of pigs, may be required at the tie-in point with the existing Bayu-Undan pipeline subject to the tie in design as agreed with the Bayu-Undan-DLNG pipeline owners.
Fibre optic cable	A fibre optic cable connection between the FPSO facility and Darwin may be installed. This cable may incorporate power used to boost the optic signal subject route length and system design. While the fibre optic cable route is still subject to refinement, the current premise is to follow a broadly similar route to the gas export pipeline, except for the southern end, where it may tie-in to an existing cable infrastructure subject to the selected concept. The cable may be installed using a variety of methods, including laying on the seabed and burial via trenching and jetting. The forward approvals process for this connection is subject to financial and commercial arrangements, and the timing of other customer negotiations and connections. Further information regarding layout, design and installation methodology will be addressed in an activity-specific secondary approval to be obtained in accordance with regulatory requirements at the time commercial arrangements are agreed.

* ConocoPhillips will not commence production related activities until a production licence is approved.

4.3.1 Key project stages

The key project stages summarised in this OPP are as follows:

- development drilling (phased program)
- installation, pre-commissioning and commissioning of the FPSO facility, subsea production system, supporting in-field subsea infrastructure, gas export pipeline and fibre optic cable
- operations
- decommissioning.

Onshore support facilities required during installation, commissioning and operation will be located in the existing ports such as Darwin or Port Melville. The operation of the onshore facilities will be subject to consideration under relevant NT government planning and approvals processes (as applicable) and are outside the scope of this OPP.

At this early stage of the project design phase, specific details on the exact volumes of discharges and emissions are not yet available. These details will become available as the engineering design progresses and will be included in the activity-specific EPs, which will be submitted for NOPSEMA acceptance prior to the activity commencing. This OPP provides conservative estimates or broad ranges of likely discharge and emissions volumes to inform a robust environmental impact and risk identification and evaluation.

Caldita Field

Potential future staged development of the Caldita Field has been considered as part of the project. While the concept to develop the Caldita Field is subject to further engineering and economic assessment, the proposed concept is for a subsea tie-back to the FPSO facility in the Barossa Field. The development of the Caldita Field will be within the Barossa offshore development area **(Figure 4-2)** and will broadly involve the same key project stages and activities as those used in the development of the Barossa Field:

- development drilling (single or phased program)
- installation and commissioning of in-field subsea infrastructure to connect to the Barossa FPSO facility
- operations
- decommissioning.

It is not envisaged that the Barossa FPSO facility will be relocated, nor is a new gas export pipeline expected to be constructed for the development of the Caldita Field. Provisions required for future potential development of the Caldita Field will be incorporated into the Barossa FPSO facility and subsea architecture design. For example, spare riser slots or the reuse of existing riser slots can be used for connecting in the Caldita Field.

Future engineering work and/or subsurface requirements will further define the engineering concept and the Caldita in-field subsea infrastructure would comprise the same key elements as for the Barossa Field, as summarised in **Table 4-4**. Refer to **Section 4.4.3** for discussion of an alternative concept to develop the Caldita Field using an unmanned WHP. Should alternate engineering approaches be progressed for the development of the Caldita Field, the description of key activities and aspects in this OPP (**Section 4.3.5**) are sufficiently representative to incorporate potential future design changes.

4.3.2 Development drilling

The proposed production wells may be drilled using a moored or semi-submersible MODU, or dynamically positioned drill ship (**Figure 4-4**). The approach selected will be influenced by the final well layout and detailed in the activity-specific EP.

Wells will be drilled using directional drilling, a technique that allows wells and subsea facilities (e.g. manifolds) to be clustered in drill centres. Directional drilling will allow multiple reservoir targets from drill centre locations, with each capable of accommodating multiple well slots.

It is anticipated that the development drilling program for the project will be undertaken in multiple phases with the drilling and completion of an individual well expecting to take up to four months (**Table 4-3**). While the exact number of wells to be drilled in each phase is yet to be determined, the total number is anticipated to be in the order of 10–25 subsea wells. An indicative number of wells for each phase is provided in **Table 4-3**. The number of wells and their locations will seek to optimise the recovery of gas and condensate fluids from the reservoir. Note that the duration of the program is subject to availability of the MODU/drill ship, well design, weather conditions and operational efficiencies and will be defined more precisely in the activity-specific EP.

a) Semi-submersible MODU b) Drill ship

(source: Petro.No 2017, Maritime Connector 2017)

Figure 4-4: Example of a semi-submersible MODU and a drill ship

Table 4-3: Proposed development drilling program summary

Development drilling phase	Proposed number of wells[1]	Expected duration of drilling program (maximum)[2]	Target date/timeframe
1	6 to 8+	24–32 months	Approximately 6 months–2 years post-FID
2	4 to 7+	16–36 months	Approximately 4 years post first gas
3(+)	0 to 10+	0–40 months	During operations – as required following future near-field exploration campaigns in the Barossa offshore development area. This may also include the development of the Caldita Field if the reservoir is deemed economically viable.

[1] The number of wells drilled during Phase 2 and 3(+) will be dependent on the production of the wells drilled during the Phase 1 development drilling program. However, the total number of wells drilled for all phaser is anticipated to be in the order of 10–25.

[2] Based on the assumption of using a single MODU/drill ship. However, use of an additional MODU/drill ship for concurrent drilling activities may be considered depending on availability.

Based on data from previous appraisal drilling campaigns, naturally occurring radioactive materials (NORMs) are not anticipated within the Barossa offshore development area during development drilling or operations (i.e. production) and are not considered further within this OPP. However, should NORMS be encountered during any stage of the project, the management of NORMs will be addressed through the EP process in accordance with the OPGGS (E) Regulations.

4.3.2.1 Drilling method

The upper sections of the wells will be drilled riserless, using seawater with high viscosity gel sweeps (i.e. water based mud (WBM)). The WBM will be circulated to the seabed with the drill cuttings accumulating close to the wellhead. It is considered standard industry practice to return drill cuttings and WBM to the seabed when drilling the upper sections of the well. Once the upper sections of the well have been drilled and cased, a blowout preventer (BOP) and riser will be connected to the wellhead. When drilling the lower sections of the well, the drilling fluids and cuttings will be circulated to the MODU/drill ship. The lower sections targeting the reservoir may be drilled using a synthetic based mud (SBM). SBM is preferable for drilling the deeper well hole sections for a variety of reasons, including improved wellbore stability and suitability of the mud system for higher temperature applications. The drill cuttings from these sections will pass through solids control equipment to reduce the amount of residual SBM on cuttings and then discharged overboard. The reclaimed SBM will be retained onboard the MODU/drill ship and recycled into the mud system.

As each section of the well is completed, a protective steel casing will be run and cemented in place. This steel casing and cement will isolate each hole section from the subsequent hole sections and provide stability. The final steel casing will provide a conduit for wellbore production to the seabed production tie-in. Cementing of the well casings may result in the release of small amounts of cement (in the order of approximately < 50 m^3–100 m^3 per well) when the cement mixture is circulated to the seabed during grouting of the surface casing strings or when surplus fluids require disposal after cementing operations. Cementing fluids used can include cement, surfactants, defoamers, lignins and inorganic salts.

The BOP system will provide secondary well control during drilling. The BOP system is comprised of a series of hydraulic rams capable of isolating the well in an emergency. The BOP system will be configured with hydraulic rams capable of shearing the drill pipe and isolating the wellbore if required. The hydraulic pressure rating of the BOP system will be sufficient to overcome formation pressures encountered during development drilling, whilst at the same time shearing the drill pipe if necessary.

Once the well has been drilled and completed, a permanent subsea wellhead known as a 'Christmas tree' is installed and the well will be cleaned-up, tied into the production system and commissioned for production.

4.3.2.2 Drilling fluids

Drilling fluids (i.e. WBM and SBM) are used in the drilling process to lubricate and cool the drill bit, maintain overbalanced conditions, and remove drilling cuttings from the wellbore. Drilling fluids consist of a base fluid with a range of solid and liquid additives to produce specific fluid properties (including density, salinity, pH and viscosity).

The general constituents of drilling fluids include:

- WBM – seawater or freshwater base fluid, bentonite, barite, brine and gellents (e.g. guar gum or xanthum gum)
- SBM – synthetic base fluid (which may consist of olefins, paraffins or esters), organophilic clays, barite, fluid loss control agents, lime, aqueous chloride, rheology modifiers, bridging agents and emulsifiers.

The specific drilling fluid formulation varies based on the technical drilling requirements for each hole section. The drilling fluid selected is either mixed on the MODU/drill ship, or received pre-mixed, and stored in a series of tanks onboard the MODU/drill ship. The selection of drilling fluids will be undertaken once detailed well design information is available so that drilling fluids are appropriate for the drilling conditions. The selection of drilling fluids and other substances routinely discharged to the marine environment will follow an environmental risk assessment and approval process.

The expected volumes of drill fluids associated with development drilling wells will be further defined and accounted for in the activity-specific EP once development well design requirements have been determined. The well design for the 2017 Barossa appraisal drilling campaign estimated the volume of drill fluids (combining WBM and residual SBM on drill cuttings) to be discharged would be in the order of 1,700 m^3 per well.

4.3.2.3 Drill cuttings

While drilling with WBM, cuttings will either be discharged at the seabed while drilling the riserless well sections, or returned to the MODU/drill ship following installation of the riser. Drill cuttings discharged directly to the seabed are expected to accumulate close to the wellhead (see **Section 6.4.8.3** for further discussion based on observations during previous appraisal drilling and the results of modelling). On return to the MODU/drill ship, the drilling fluid and cuttings will be separated by the solids control equipment and drill cuttings discharged overboard. When using SBM, the solids control equipment will reduce the residual base fluid on cuttings content prior to discharge overboard. Residual base fluid on cuttings will be less than 10% by weight (w/w), averaged over all well sections drilled with SBM.

The expected cuttings volumes will be further defined in the activity-specific EP once development well design requirements have been determined. The well design for the 2017 Barossa appraisal drilling campaign estimated the volume of drill cuttings (combining WBM and residual SBM) to be discharged would be in the order of 500 m^3 per well.

4.3.2.4 Blowout prevention

A BOP will be installed (latched) on the wellhead to provide a secondary barrier to manage well integrity by providing a means to seal, control and monitor the well during drilling operations. The typical BOP includes annular preventers and pipe rams, both of which are designed to seal around tubular components in the well. In addition to this, blind/shear rams are installed capable of shearing the drill pipe. The BOP may be used if there is an influx of formation fluid, referred to as a 'kick', from the wellbore as a result of encountering a permeable formation that has a higher pore pressure than the hydrostatic pressure of the drilling fluid. In this scenario, the appropriate component of the BOP will be activated to close or 'shut the well in' and stop the influx of fluids. The drilling crew should then be able to regain control of the well using procedures such as increasing the drill mud weight to overbalance the formation pressure and circulate out the influx under a controlled manner. This should allow the BOP to be re-opened once the well has stabilised and it is safe to continue drilling operations.

Function and pressure tests of the BOP will be regularly conducted during drilling operations to ensure the system reliability is maintained. The operation of the BOP (valves) uses open hydraulic systems and each time the BOP is operated (including testing) a small volume of BOP hydraulic fluid is discharged to the water. The BOP hydraulic fluids generally consist of water mixed with a glycol based detergent or equivalent water based anti-corrosive additive.

Each function or pressure test of the BOP will result in approximately 250 L–300 L of BOP hydraulic fluid (i.e. hydraulic fluid chemical diluted in water), depending on the BOP specifications, being discharged to the marine environment.

ConocoPhillips also has additional contingency plans in place in the event of a loss of well control, including spill response, side track relief well drilling, well capping and existing contracts with spill response agencies to facilitate efficient implementation of spill response measures (**Section 6.4.10**).

4.3.2.5 Well completions

Following drilling operations, the well will be completed in preparation for production. Well completion operations include:

- casing of the well with steel pipe and cementing of the casings to maintain its integrity
- perforation of the casing, or use of a pre-perforated liner, to allow reservoir fluids to flow into the well
- installation of a lower production completion package with down-hole sand control capability and zonal isolation packers to prevent formation solids from entering the well
- installation of a subsea Christmas tree, which consists of a number of valves that control the well flow.

Well completion fluids will be circulated through the well to confirm the well is clear of solids/debris and prevent blockage in the reservoir. Small amounts of well completion fluid, in the order of 100 m^3 per well, may be released to the marine environment provided it meets oil-in-water threshold criteria. Well completion fluids will be assessed against the ConocoPhillips drilling fluid environmental risk assessment and approval process to determine acceptability.

4.3.2.6 Well clean-up and testing

Prior to commencement of production, the well will be cleaned up to remove any remaining drilling fluids, solids, debris and completion fluids using the MODU/drill ship or FPSO facility. The well flow testing will also be used to obtain samples from the reservoir and collect information on reservoir characteristics. Well clean-up and testing will also validate and protect the integrity of the well, and subsea and FPSO facility infrastructure prior to them being commissioned.

During well clean-up, the reservoir fluids stream may flow through separator equipment to separate the fluid phases. Methanol or glycol may be used during the test to suppress hydrates and allow the well fluids to maintain flow. Gas from the separator is piped to a gas flare (burner) and burnt off. The condensate phase will be piped to the burner booms where it will be flared off with the gas phase. Any water from the separator will be discharged overboard, provided it meets oil-in-water threshold criteria.

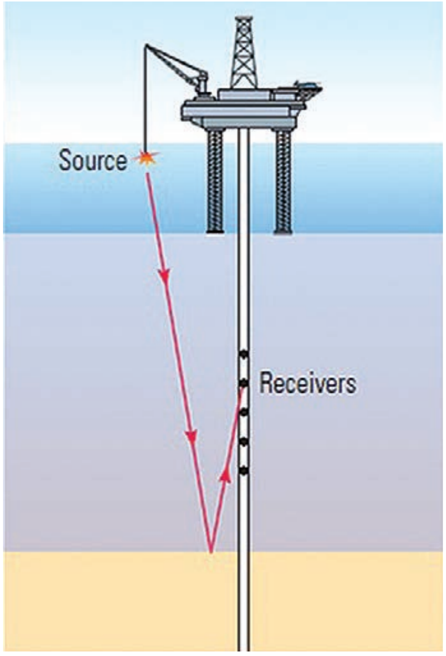
Well testing will be undertaken in accordance with the approved WOMP as required under the Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011. Well specific guidelines will contain information related to individual well tests, including information such as target flow rates, flow periods and shut-in periods.

Following successful well clean-up and commissioning using the MODU/drill ship or FPSO facility, the well may remain shut-in for a period of time until it commences production permanently to the FPSO facility.

4.3.2.7 Vertical seismic profiling

Vertical seismic profiling (VSP) may be undertaken on individual development wells. This technique involves deploying a small sound source from the MODU/drill ship below the water surface while receivers are positioned at different depths within the drilled hole (**Figure 4-5**). Alternatively, in some circumstances a mobile sound source (e.g. onboard a small vessel) could be used to undertake "walkaway" VSP. In this instance, the sound source is moved progressively further away from the development well to allow more continuous coverage. VSP provides a seismic image of the geology in the immediate vicinity of the well, with the survey taking approximately eight to 24 hours per well (i.e. in the order of 25 days in total over the duration of the phased development drilling program).

The sound source used for VSP of individual wells is typically much smaller than that used during a 2D or 3D marine seismic survey, e.g. an airgun array of approximately 450 cubic inch (three by 150 cubic inch) capacity is likely to be used. For each depth level the airgun will generate acoustic pulses five times at approximately 20 second intervals, lasting between five to seven minutes. Receivers will be placed down-hole at selected depths or at regular intervals on the seabed away from the well for walkaway VSP to record acoustic signals. Note that for some VSP arrays (i.e. down-hole) it may not be possible to shut down the airgun operation immediately due to technical, equipment and safety constraints.



(source: Shafiq et al. 2015)

Figure 4-5: Schematic showing VSP from MODU

4.3.3 Installation, pre-commissioning, commissioning and operations

Key activities that will be undertaken during this stage of the project include:

- seabed intervention – may be required to provide stability for subsea infrastructure
- installation of the gas export pipeline, including tie-in to the existing Bayu-Undan to Darwin pipeline
- subsea infrastructure installation on the seabed (may involve heavy lift operations)
- tow-out and installation of the FPSO facility at the defined mooring location (may involve heavy lift operations), and hook up of subsea infrastructure
- integrity testing of the subsea production system and supporting subsea infrastructure (hydrotesting) and preparing flowlines and the pipeline for hydrocarbons (dewatering and drying)
- testing, refinement and monitoring of all FPSO facility systems (e.g. flaring system)
- operations – including maintenance.

4.3.3.1 FPSO facility, subsea production system and supporting in-field subsea infrastructure

FPSO facility

The FPSO may be a ship shaped floating facility, with the hull being either a converted very large crude carrier, or a new build hull. Alternative non-ship shaped FPSO facility designs may also be considered. The facility will enable in-field hydrocarbon processing and condensate storage and export. The processed dry gas will be sent via a gas export pipeline, to a proposed tie-in point on the existing Bayu-Undan to Darwin gas export pipeline for transport to the DLNG facility. An example FPSO facility, the FPSO Hai Yang Shi You 117, is shown in **Figure 4-6**.

Figure 4-6: Example FPSO facility

A ship shaped FPSO facility will be permanently moored using a turret mooring system to enable positioning in all metocean conditions. The mooring system will have multiple legs anchored to the seabed. The FPSO facility shall remain on station and be able to weather 10,000 year cyclonic metocean conditions, ensuring no loss of cargo containment or structural integrity. A ship shaped FPSO facility may have thrusters to enable heading control of the facility to assist with operational requirements.

The main design elements, facilities and services of the FPSO facility are likely to include:

- subsea control system to manage operation of the in-field subsea infrastructure, for example the control of the subsea chokes and valves, in the Christmas trees and manifolds, working together with the inlet production manifold systems to receive production fluids from the production wells in a controlled manner
- chemical injection package to provide dosing chemicals such as mono-ethylene glycol (MEG)/ methanol (depending on the design of the FPSO facility), scale/corrosion/wax inhibitors and hydraulic fluids. These chemicals ensure flow assurance is managed and maintained
- facilities for gas-liquid separation. The production separation system removes liquids from the gas facilities to separate condensate and produced water (PW)
- facilities where the gas is processed to meet the feed gas requirements of the DLNG facility (e.g. dehydration, hydrocarbon dewpoint and partial carbon dioxide (CO_2) removal)
- mercury removal and disposal of hazardous waste to shore
- facilities where the hydrocarbon liquid (condensate) is stabilised to meet market delivery requirements, stored and offloaded
- compression facilities to discharge gas at sufficient pressure to allow delivery to the DLNG facility
- gas turbine generators for supply of electricity power requirements
- accommodation facilities for approximately 150 offshore personnel
- reverse osmosis plant to provide potable water for both process and personnel needs
- cooling water systems in which seawater is used as a heat-exchange medium for the cooling of facilities, particularly the gas-liquid separation and processing facilities
- facilities for the treatment of PW for disposal overboard
- sewage and greywater treatment systems to manage wastes generated from domestic processes such as toilets, dishwashing, laundry and showers
- open and closed drainage systems to separate deck drainage (consisting of mainly washdown water or rainwater) from areas which contain hazardous and non-hazardous materials

- bilge system to treat and remove bilge water that has collected in any watertight compartments at the base of the FPSO facility hull
- ballast water system to manage stability
- facilities for the separation and regeneration of MEG (if this method of flow assurance is selected)
- storage facilities for fuel and production support chemicals, such as MEG/methanol and scale/corrosion/wax inhibitors
- helicopter deck to enable transfer offshore personnel.

Facilities and services that pose the lowest safety risk will be located closest to the accommodation. Spacing between facilities will also be optimised during the engineering design process to minimise the overall risk.

The processes on the FPSO facility separate the reservoir fluids into separate gas and condensate streams. The gas stream is dehydrated, stripped of condensate, treated for partial CO_2 removal and compressed for export via the gas export pipeline. The export pipeline will operate dry and free of liquids which protects the pipeline against internal corrosion. Recovered condensate will be cooled and stabilised and stored in tanks in the hull of the FPSO facility. During normal operating conditions, a portion of the produced gas is conditioned as fuel gas for the gas turbine drivers (compressors and power generation). During periods when the normal gas source is unavailable the power generation system will operate on low sulphur diesel in compliance with MARPOL. An indicative process flow diagram for the FPSO facility is shown in **Figure 4-7**. Refer to **Section 4.3.5.8** for further detail on planned discharges from the FPSO facility.

The partial offshore CO_2 removal is currently planned to be achieved via a two stage membrane system that will reduce the CO_2 content of the feed gas stream to a level compatible for processing at the existing DLNG facility (in the order of 6%). This system is not a method of stripping CO_2 or other GHGs out of exhaust streams associated with fuel gas consumption or other point sources. Rather, it is a method of treating the raw feed gas to pipeline specification required by DLNG, removing bulk CO_2 from the system early and thus help reduce process equipment sizing downstream. Membrane separation is based on the selective diffusion of gas through a permeable membrane, in which gases are separated on the basis of their solubility and diffusivity through the membrane barrier when under an imposed pressure gradient. Constituent components of the natural (feed) gas diffuse at different rates: H_2O, CO_2 and H_2S have high permeation rates, methane has a medium rate and heavier hydrocarbons like butane have a much lower permeation rate. The two stage process has the advantage of much lower losses of methane, typically 2-3% (as compared to 6-8% for a single stage system).

As some methane is carried over post CO_2 removal process, the excess CO_2 stream removed from the feed gas will be routed for treatment to the thermal oxidizer to burn off residual methane ahead of discharge to atmosphere. Methane is known to be approximately 30 times more potent as a GHG than CO_2. Therefore the thermal oxidizer is used to combust the remaining methane in the discharge stream to reduce the total GHG potency in the emissions.

For reliability and operability, an acid gas flare will be used as a back-up to the thermal oxidizer. Part of the second stage CO_2 membrane's permeate is expected to be used as a portion of the fuel gas for gas turbines, and hence reduce the overall greenhouse gas emissions.

An alternative to the membrane system being considered to remove bulk CO_2 from the feed gas is an amine system. The amine units are large contactors allowing for the chemical bonds to form trapping CO_2 until the solvent is saturated with CO_2 and requires regeneration. In amine based processes, chemical reactions bind CO_2 to amines at low temperatures, and regeneration occurs by breaking these chemical bonds with heating.

At this early stage of conceptual design, the optimal technology to achieve CO_2 removal is yet to be selected. Irrespective, the nature of the emissions profile and management options remain similar. These will be subject to further engineering evaluation as the project progresses.

Condensate that is recovered from the gas is stabilised, cooled and stored in tanks in the hull of the FPSO facility. The condensate is then periodically offloaded to export tankers using a tandem offloading system, similar to that used on many FPSOs around the world.

The flow assurance management strategy for the project is yet to be defined and may include the use of either MEG or methanol as the hydrate inhibitor. Both MEG and methanol have a low environmental risk as they are water soluble, do not bioaccumulate, and have very low toxicity (Hook and Revill 2016). Should continuous MEG injection be selected for hydrate prevention in the production flowlines, the FPSO facility may include processes to regenerate the MEG and treat the PW stream. MEG/methanol would be treated as part of the PW stream to remove both free oil and dissolved hydrocarbons so it meets a discharge limit of 30 mg/L oil-in-water over any 24-hour period prior to discharge to the marine environment.

Based on the understanding of the reservoir fluids, very low concentrations of mercury may be present in the gas stream which may need to be removed to meet market specification requirements for the condensate product. If required, mercury may be removed through either absorbent material in a mercury removal unit or decanting of mercury in gas drums associated with the processing facilities on the FPSO facility. The mercury removal unit will consist of absorbent beads that collect mercury as the gas passes through the unit. When the absorbent beads in the mercury removal unit become saturated, they will be packaged and transported to shore for disposal at an approved facility. It is expected that the absorbent material will be replaced approximately every 4–5 years. In the case of the gas drums, mercury that condenses from the gas stream in the processing facility would be collected within these drums and periodically decanted into sealed storage containers, and transported to shore for disposal at an approved facility. The frequency at which the containers are transported to shore is dependent on the final design and size of the sealed containers, and could range to from every few months, annually or less frequently.

The stored condensate is periodically offloaded to export tankers moored in a tandem configuration with the FPSO facility. In tandem offloading, the tanker is positioned at a safe distance (e.g. 100 m) from the FPSO facility with its bow generally in line with the stern of the FPSO facility. Condensate will be offloaded to tankers via a stern offloading hose system. Based on the expected condensate production rate of the field, the frequency of vessel movements relating to the export of condensate is expected to be one shuttle tanker every 80–100 days, depending on vessel size, production rate and field composition. Liquefaction and offtake of LNG is proposed to occur at the existing DLNG facility.

On completion of installation activities, subsea infrastructure (in-field and gas export pipeline) and the FPSO facility will be commissioned. Gas stream will be introduced into the system by partially opening a single well to enable safe pressurisation. The gas will then begin to flow through to the FPSO facility and the first gas commissioning activities will commence. While the FPSO facility design is under development, the following are likely to represent key steps involved in the commissioning process:

- initial cold venting to clear nitrogen from the inlet system piping
- early establishment of the flare system, including lighting of the pilot burner system
- the topside processing facilities will be pressured up one section at a time to test for leaks and purge through to the flare
- the condensate handling system will be commissioned
- the main gas processing path will be opened in small steps to check for leaks and will purge through to the flare
- fuel gas will initially be used to switch power generation from diesel fuel to gas fuel
- when export quality gas is being produced, the gas will be directed to the gas export pipeline
- following establishment of specification gas delivery to the gas export pipeline, production rates will be stepped up slowly to raise production to system capacity.

The steps for initial commissioning are expected to take a few months as the complex systems are started with produced gas. Produced gas is needed to run the equipment and until all the processes are functioning sufficiently to deliver specification gas, the gas must go to the flare.

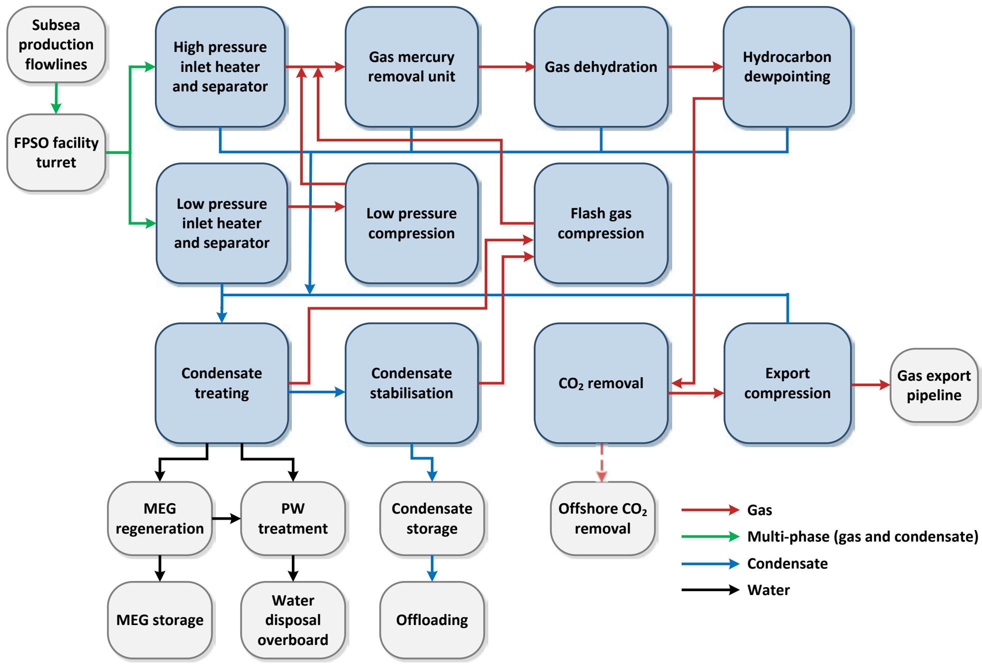


Figure 4-7: Indicative process flow diagram

Subsea production system and in-field subsea infrastructure

The main categories of subsea infrastructure that will be installed for the project are summarised in **Table 4-4**. **Figure 4-8** shows indicative locations of the subsea wells and drill centres with connecting subsea infrastructure. **Figure 4-9** provides a general layout of the subsea infrastructure.

Following installation and hook up of the in-field subsea infrastructure, all subsea flowlines, umbilicals and risers will be hydrotested to confirm their integrity. This will be undertaken using treated seawater and hydrotest fluids, with the internal pressures monitored to detect any leaks. Further information on hydrotesting is provided in **Section 4.3.5.8**.

Table 4-4: Key in-field subsea infrastructure descriptions

In-field subsea infrastructure	Description
Flowlines – production, service and MEG supply (includes flowline end terminations (FLETs) and in-line tees (ILT))	Subsea flowlines will transport production fluids (gas and condensate) from subsea wells and manifolds to the FPSO facility. The flowlines will not be trenched and may be either rigid, flexible or bundled. If flexible flowlines or bundles are not used, flowline lateral buckling or walking is predicted for the production and service flowlines and will be mitigated by installing displacement initiators (e.g. skids, counteract structures) at intervals along the flowline length or pinning the flowlines in place.
Manifolds (includes connectors, valves and mud mat foundation)	Manifolds are structures that co-mingle and direct production fluids (gas and condensate) from multiple wells into the in-field flowlines and / or service lines, which are connected to the FPSO facility. It is anticipated that all manifolds will be offset from the route of the flowlines and tie-in to ILT/FLET on the flowlines. The manifold structures foundations are likely to be either gravity or suction based and have a separable shallow skirt mudmat.
Christmas trees/wellhead (includes installation and workover control system and well work over riser system)	The Christmas tree is installed on the wellhead, to enable reservoir fluids to flow from the well into the manifolds, and consists of an arrangement of valves, controls and instrumentation. The Christmas tree will have safety valves to enable isolation of the reservoir in the event of a mechanical failure or loss of system integrity and a 'choke' valve to control fluid flow and pressure from the well to the flowline.
Umbilicals (includes umbilical termination assemblies (UTAs))	Umbilicals transfer power (electrical and hydraulic fluid), chemicals (such as MEG, methanol and scale/corrosion/wax inhibitor), communications to the wells, Christmas trees, manifolds and other subsea systems requiring remote control. The umbilicals will connect to the FPSO facility through UTAs.
Risers	Flexible risers connect the end of the flowline near the FPSO facility to the turret and accommodate movement of the FPSO facility. The production flowlines and risers transport the production stream including produced hydrocarbons, PW and injected fluids such as MEG, methanol and scale inhibitor. Orientation of the risers will take into consideration space requirements so that the individual risers do not contact the FPSO facility hull or mooring lines.
Pipeline end termination (PLET)	The PLETs are located at either end of the new gas export pipeline and allow connection of the pipeline to the FPSO facility and Bayu-Undan to Darwin pipeline. The PLET at the FPSO facility includes a connection for a seabed pig launcher, while the PLET at the Bayu-Undan to Darwin pipeline may include a connection for a seabed pig receiver (subject to the tie-in design). Refer to **Section 4.3.3.2** for further detail.

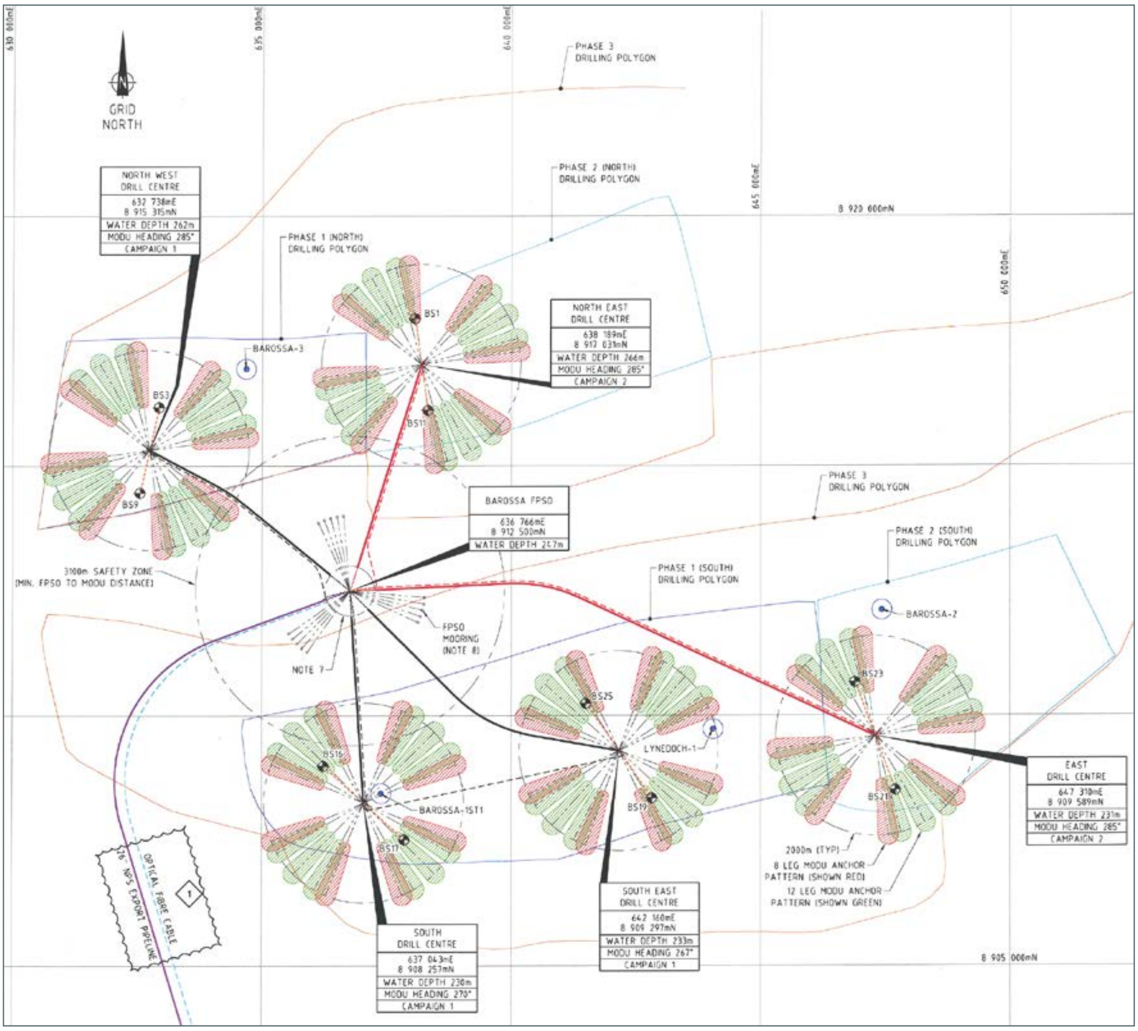


Figure 4-8: Indicative field layout showing subsea facilities

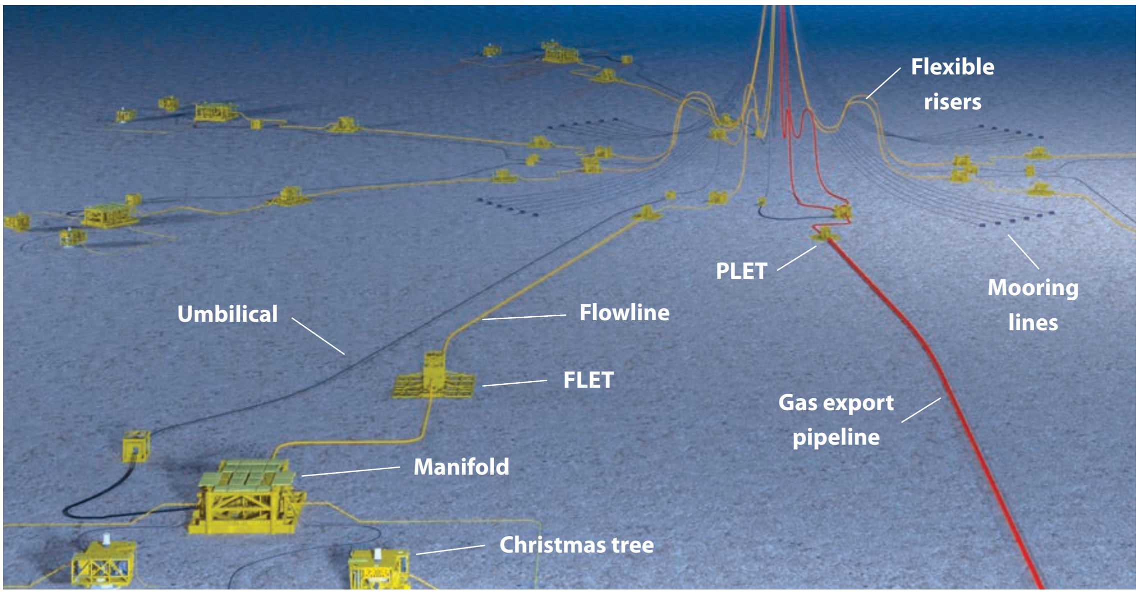


Figure 4-9: General layout of the in-field subsea infrastructure

4.3.3.2 Gas export pipeline

The FPSO facility will be connected to the existing Bayu-Undan to Darwin pipeline (subject to suitable commercial arrangements being in place) via a new dry gas export pipeline. The new section of pipeline will have a length in the order of approximately 260 km–290 km and may take approximately six to 12 months to install on the seabed (depending on the extent of seabed intervention required such as preparation of the seabed for laying and stabilisation, with options described further later in this sub-section and in the assessment of alternatives in **Section 4.4.3**). Note the duration is subject to availability of the pipeline/pipelay installation vessels, pipeline route and design, weather conditions and operational efficiencies and will be defined more precisely in the activity-specific EP.

The proposed connection to the existing pipeline will be subsea and no permanent surface facilities are required at, or in the vicinity of, the tie-in. The tie-in of the new gas export pipeline to the existing pipeline may occur in the early or latter stages of the installation phase of the project. The scheduling of the tie-in of the new gas export pipeline to the existing pipeline, in relation to the installation of the new gas export pipeline, is subject to commercial arrangements which are yet to be negotiated.

A subsea pig receiver structure (approximately 6–9 m in length) may be located at the tie-in of the existing pipeline to facilitate receipt and recovery of intelligent pigs launched from the subsea launch facilities at the FPSO; such a structure could be required in the case of a two phase tie-in. Pigging activities at the tie-in location may occur once every approximately 2–5 years. Each pigging operation will result in very small volumes (< 5 m^3) of dry gas, corrosion inhibitor and inhibited seawater or MEG being released to the marine environment. No solids are expected to be released during pigging activities.

ConocoPhillips is proposing to tie-in to the existing Bayu-Undan to Darwin pipeline to avoid duplication of existing pipeline infrastructure within the vicinity of Darwin Harbour. This approach minimises the potential environmental impacts and risks to a number of key values and sensitivities in Darwin Harbour.

The seabed disturbance for the project, as described further in **Section 4.3.5.2**, includes the direct footprint of the gas export pipeline, as currently known from conceptual design, and associated seabed intervention techniques from physical infrastructure and physical placement of any excavated materials directly on the seabed. Localised indirect sources of seabed disturbance are also described in **Section 4.3.5.2**.

Pipeline route

The gas export pipeline route is still subject to refinement within the designated corridor **(Figure 4-3)**. As part of the forward environmental approvals process, ConocoPhillips is committed to undertaking further targeted surveys as the engineering design progresses to facilitate selection of the best route, which takes into account any potential engineering design constraints and environmental considerations. Therefore, for the purposes of this OPP, a corridor has been assessed, which encompasses both the gas export pipeline route and vessel movements associated with the installation of the pipeline. One area that may require further evaluation is a 30 km shallow water area within the pipeline corridor to the east of the Oceanic Shoals marine park **(Figure 4-12)**. Within this area of the pipeline corridor, minimum water depths are less than 30 m, with the implication that an anchored pipelay vessel and secondary stabilisation (such as trenching/dredging) may be required in this area (specifically shown on **Figure 4-12** as the 'Gas export pipeline shallow water area'). It is important to note that the pipeline route will only comprise a small portion (<0.01%) of the pipeline corridor shown in **Figure 4-3**. The typical arrangement of the gas export pipeline on the seabed, excluding seabed intervention, is shown in **Figure 4-10**.

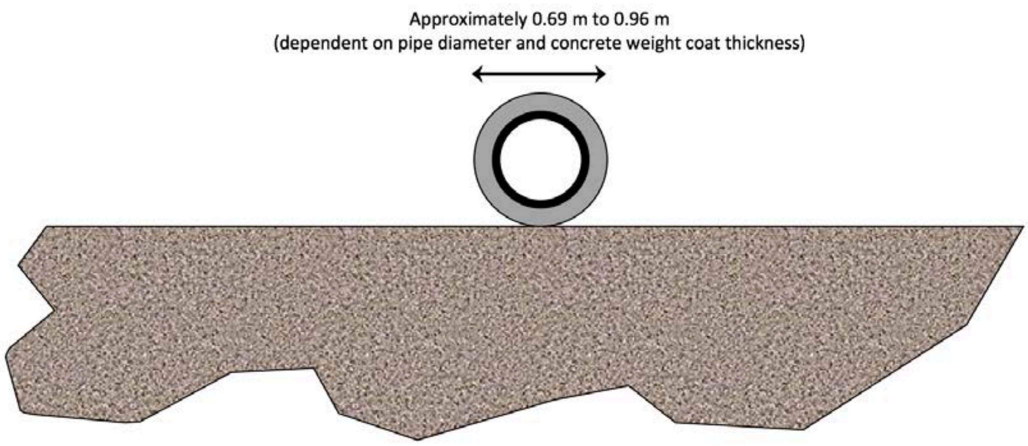


Figure 4-10: Typical arrangement of the gas export pipeline on the seabed

To provide some initial context to inform project design, a preliminary geophysical survey was undertaken within the pipeline corridor by Fugro in November 2015 to gain an understanding of the water depths and seabed features that may be encountered. A subsequent bathymetric and geophysical survey that mapped the water depth and seabed topography within the pipeline corridor was completed by Fugro in August 2017. In general, the surveys observed that the seabed along the length of the corridor varied from relatively smooth and gently sloping to irregular areas including sandwaves, seabed channels, ridges and mound structures with steep gradients (Fugro 2016, 2017). An indicative profile of the bathymetry within the gas export pipeline corridor is shown in **Figure 4-11** (Fugro 2016).

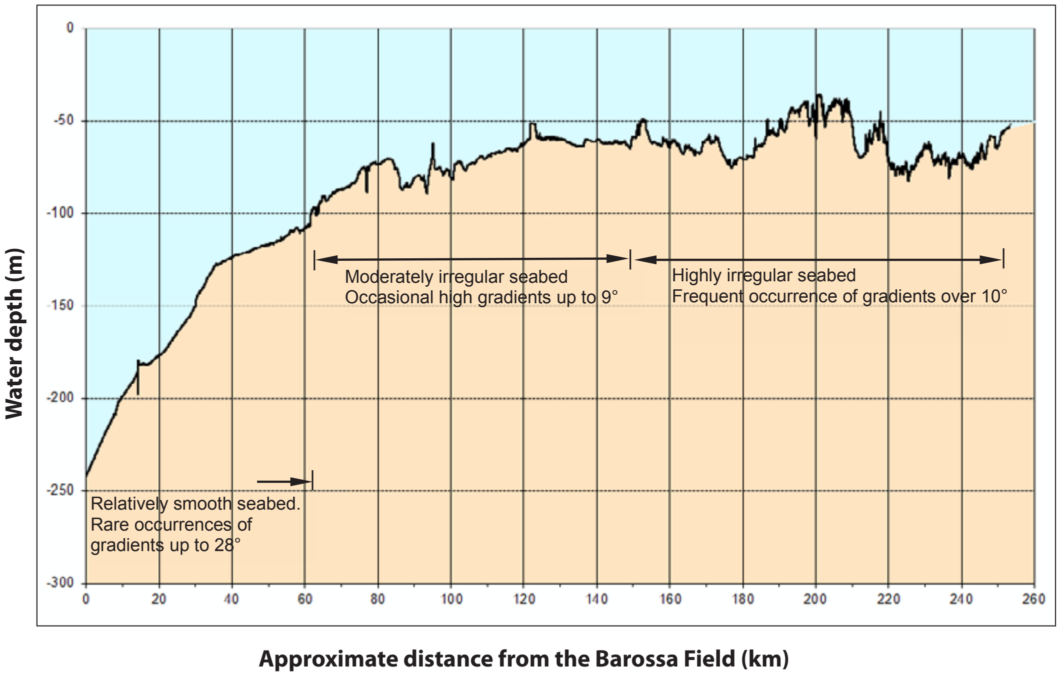


Figure 4-11: Bathymetry surveyed along the length of the gas export pipeline corridor

Evaluation of the data gained from the geophysical surveys, combined with the review of bathymetry, water depths and seabed features (including sediment type and topography), identified several key design, engineering and environmental considerations, which were taken into account in the definition of the gas export pipeline corridor. While ConocoPhillips recognises that a portion of the pipeline corridor intersects the Oceanic Shoals marine park to the west of the Tiwi Islands **(Figure 4-3)**, routing of the gas export pipeline further to the east to remain outside of the marine park in this area has the potential to result in greater environmental impacts during pipeline installation. Water depths between the pipeline corridor and the Tiwi Islands are indicated to be as shallow as approximately 4 m, as highlighted on Admiralty Charts (as shown in **Figure 4-12**).

Since the OPP public consultation period, further engineering definition has been undertaken to understand potential pipeline routing and thus, refine the gas export pipeline corridor. Given that draft management plans for the North AMPs continue to be developed the refined pipeline corridor continues to maintain the option to install the gas export pipeline immediately adjacent to the east of the Oceanic Shoals marine park **(Figure 4-3)**. While current understanding of the requirements to install the pipeline has identified that installing the pipeline outside the marine park will require greater seabed intervention, the pipeline corridor has been limited to the area identified to require the least seabed intervention for a route located outside of the marine park. Refer to **Section 4.4.3 (Table 4-10)** for a comparative assessment of the pipeline corridors and route options considered for the project.

Analyses of the geophysical and bathymetric survey data have confirmed that the minimum water depth is approximately 30 m within the gas export pipeline corridor (Fugro 2016, 2017), with the exception of a shallow water area immediately to the east of the Oceanic Shoals marine park **(Figure 4-12)**.

A range of seabed intervention techniques to support pipeline installation are currently being considered and are described in more detail below. Refer to **Section 6** for discussion regarding potential impacts associated with seabed intervention techniques that may be used during installation of the gas export pipeline, subject to final routing.

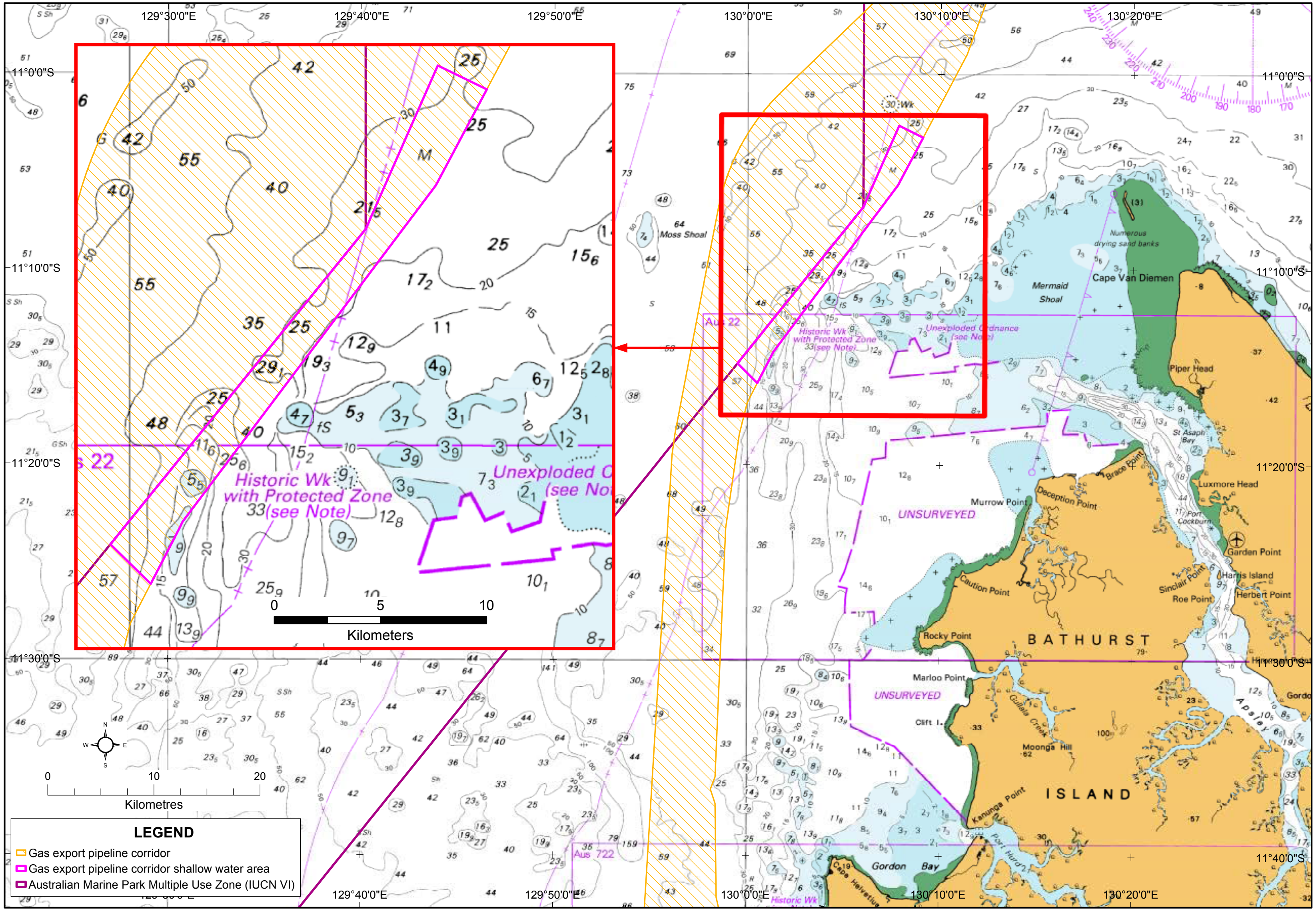


Figure 4-12: Shallow water area of the gas export pipeline corridor east of the Oceanic Shoals marine park

ConocoPhillips is committed to a process to:

- undertake further targeted geophysical and environmental surveys and engineering review to select a pipeline route and installation method that reduces the environmental impact to as low as practicable, while taking into consideration the various environmental values/sensitivities within the defined corridor
- maintain close engagement with Parks Australia regarding the proposal and the key considerations that will determine the viability of route options and the least environmental impact among different route alternatives.

Pipeline installation

The gas export pipeline will consist of a 24–26-inch diameter carbon-steel pipeline that has an external anti-corrosion coating and anodes to maintain structural integrity, and a concrete coating to provide stability and mechanical protection.

The gas export pipeline will be laid using a continuous assembly pipe-welding installation method. This involves the assembly of the single pipe joints (approximately 12 m in length) in a horizontal working plane (the firing line) onboard the pipelay vessel. The pipe joints are then welded together, inspected and then coated as they progress through the various firing line work stations. As welding progresses, the pipeline will be gradually lowered to the seabed behind the pipelay vessel using an S-lay method, with the S notation referring to the shape of the pipeline as it is laid onto the seabed. The curvature of the upper section of the pipeline lowered to the seabed is controlled by a steel structure, known as a stringer, fitted with rollers to support the pipeline. The curvature in the lower section of the pipeline is controlled by the holdback tension placed on the pipeline by the pipe tensioners (caterpillar tracks that clamp the pipe).

The type of pipelay vessel used will be dependent on a range of factors such as the final alignment of the gas export pipeline, the availability of suitable pipelay vessels in the region and the pipeline parameters (such as wall thickness and concrete weight coating thickness). Dynamically positioned pipelay vessels will be utilised for installation of the pipeline in water depths greater than 30 m. However, as the use of dynamically positioned pipelay vessels are generally limited to a minimum water depth of nominally 25 m of water, subject to vessel size, capability and pipeline parameters, an anchored pipelay vessel may be required if the pipeline remains outside the Oceanic Shoals marine park in the shallow water east of the marine park where water depths are less than 30 m **(Figure 4-12)**.

While highly unlikely, an unplanned 'wet buckle' event may occur during installation should the pipeline become twisted and fracture during pipelay, thereby causing flooding of the pipeline with seawater. In the event of a 'wet buckle' the seawater will need to be displaced from the pipeline with chemically-treated (e.g. corrosion and scale inhibitors and biocides) seawater to prevent internal corrosion, and then dewatered to facilitate continued installation of the pipeline.

The primary method of maintaining pipeline stability on the seabed, where required, will be through a concrete weight- coating. Where the required stability cannot be achieved through this means alone, several seabed intervention techniques may be used to stabilise and protect the gas export pipeline. For example, stabilisation of the gas export pipeline may be required in shallower waters to overcome the buoyancy factor of the pipeline in these depths and provide protection against rough metocean conditions that could occur during severe weather events (i.e. cyclones). While the pipeline corridor has been refined such that the occurrence of areas of significant seabed features has been minimised as much as practicable and the final pipeline route will further seek to avoid uneven seabed features wherever possible, some stabilisation (specifically span correction) may be required to mitigate rough terrain that cannot be feasibly avoided without incurring grossly disproportionate costs to the project, such as areas of irregular seabed topography.

A range of seabed intervention techniques (includes stabilisation such as pre-lay and post-lay span correction and secondary stabilisation) may be used. Stabilisation methods could include, concrete mattresses, sand/grout bags and steel structures for free span-rectification, rock bolting and gravity anchors. Secondary stabilisation such as trenching/dredging or rock dumping may be required within the shallow water area of the pipeline corridor if the final gas export pipeline corridor is located outside of the Oceanic Shoals marine park **(Figure 4-12)**.

If required, trenching/dredging in the shallow water area may involve the use of underwater ploughs and/or mechanical trenchers depending on the characteristics of the seabed. Further engineering studies will determine the extent of secondary stabilisation required for a route in the shallow water area. Where trenching/dredging is unable to provide sufficient stability, or where additional protection from other marine users is required, rock dumping will be employed using specialised vessels. It is expected that if required the rock dump or berm over the pipeline would be approximately 12 m wide at the base on the seabed. Steel structures may be installed to support the pipeline over rough, uneven or steep terrain. Rock bolting, gravity anchors, concrete mattresses and sand/grout bags may be installed to support and stabilise the pipeline. Example schematics of some of the seabed intervention techniques are shown in **Figure 4-13**.

The specific requirements for seabed intervention techniques will depend on the extent, seabed properties, equipment availability and water depth at the locations for which the intervention is required. ConocoPhillips is committed to undertaking further targeted surveys to determine the optimum route for the gas export pipeline, taking into account any potential engineering design constraints and environmental considerations. The potential environmental impacts and risks associated with seabed intervention techniques are considered in this OPP (particularly seabed disturbance and underwater noise; **Section 6.4.3** and **Section 6.4.5**, respectively) and will be assessed in detail in activity-specific EPs.

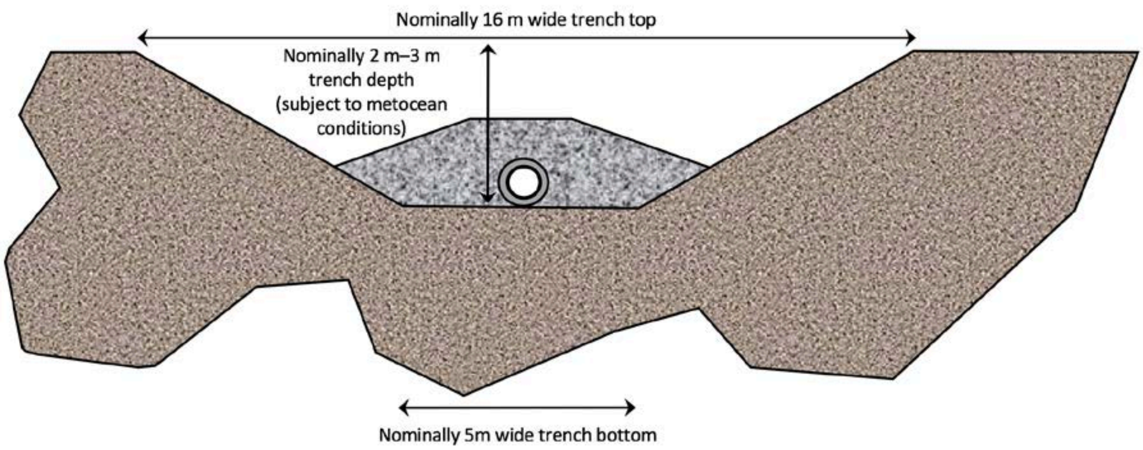
Following installation of the gas export pipeline, the following activities will be undertaken:

- flooding, cleaning and gauging
- hydrostatic pressure testing of the pipeline with treated seawater to confirm the structural integrity and to identify any potential leaks (see **Section 4.3.5.8** for further details on hydrotesting)
- dewatering of flooding fluid (see **Section 4.3.5.8** for further details on dewatering) and drying
- conditioning of the pipeline in readiness for the introduction of gas. Options being considered include conditioning the pipeline with slugs of inhibited freshwater, MEG or triethylene glycol (TEG). This is followed by purging with nitrogen and line packing, which involves a pig train driven by nitrogen being run through the pipeline (if required).

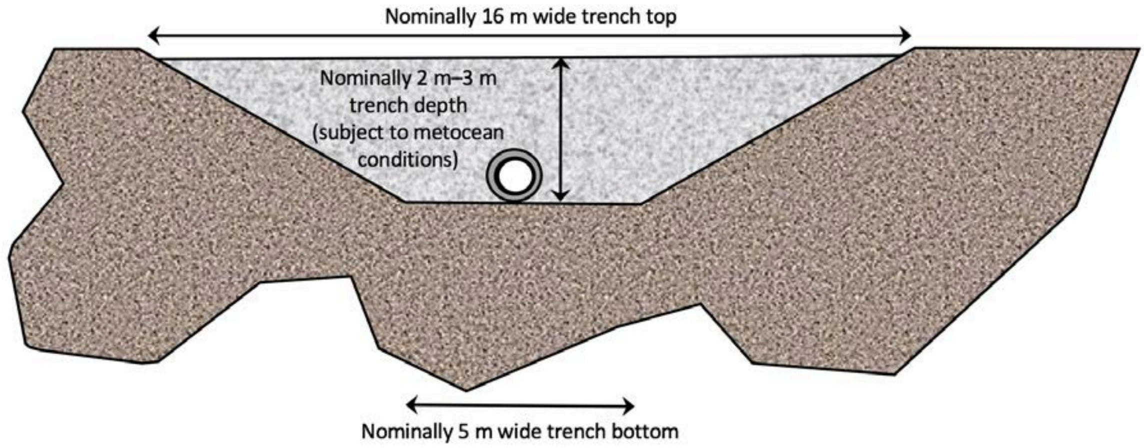
During pre-commissioning, commissioning and operation, pigging of the gas export pipeline will be required for dewatering, cleaning, gauging and to assure the integrity of the pipeline.

Gas pressure is used to push the pig into the pipeline where it then transits down the pipeline. Export gas is envisaged to drive the pig during operational pigging so no discharge of fluids is anticipated as no additional fluid is proposed to be used. However, if required, any discharges will be managed in accordance with the project Waste Management Plan, and as detailed in the activity-specific EPs.

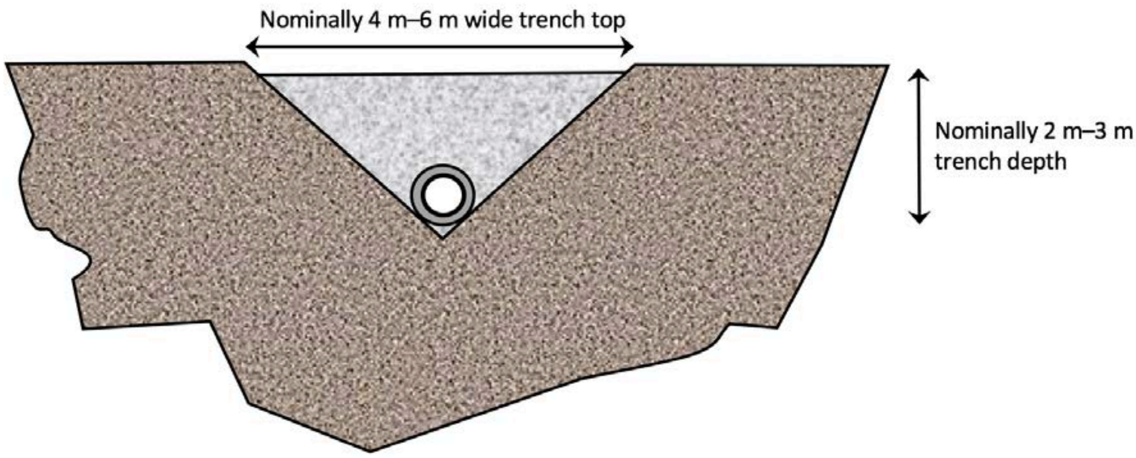
Maintenance of the gas export pipeline will be undertaken throughout operations and include regular internal and external inspections and monitoring, with intervention being performed as required to ensure the integrity of the pipeline is maintained.



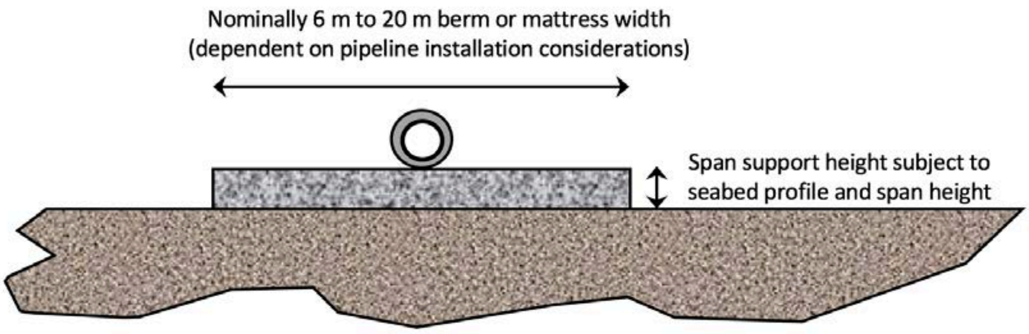
a) Pre-lay trench arrangement with rock backfill



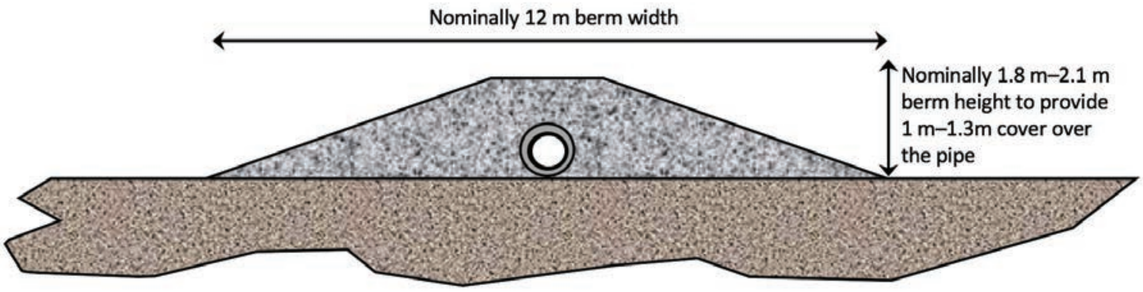
b) Pre-lay trench arrangement with sand backfill



c) Post-lay trench arrangement with sand/rock backfill



d) Typical rock berm arrangement



e) Typical span correction arrangement

Figure 4-13: Example schematics of seabed intervention techniques that may be used to install the gas export pipeline

4.3.3.3 Fibre optic cable

The fibre optic cable between the Barossa offshore development area and Darwin is the current premise to provide the project with a reliable and stable high-speed data service that allows effective and efficient operations at the FPSO facility. The cable route is subject to forward commercial arrangements and therefore the final route has not been determined. However, it is expected that the cable may follow a broadly similar route to the gas export pipeline, except for the southern end where it could tie into existing cable infrastructure. The total cable length is expected to be around 260 km–290 km in length. The fibre optic cable will take up to approximately four months to install.

The lightweight cable will vary in diameter (ranging from approximately 10 mm to 40 mm) along its length as a result of the level of armouring that is needed, which is influenced by water depth, risks to the cable and seabed type. In general, armouring will be applied where the seabed is rocky (to protect from potential abrasion) and there is a potential future risk of damage from trawling activities. Subject to the length and design of the fibre optic system the cable design may include conductive material to allow for carriage of an electrical charge of up to 5,000 volts (direct current), which is needed for the operation of the cable (signal booster) and associated equipment along its length. Insulation will also be applied to the cable so it does not generate any electric field external to the cable.

The cable will be installed using a specialised vessel and be either laid on the seabed or buried. It is expected that most of the cable will be buried to provide extra protection and stabilisation. However, the cable may be laid on the seabed where it is not feasible to bury the cable (e.g. where there are insufficient soft sediments) or where there is no threat to the cable if it is laid on the surface. Burial of the cable may be undertaken via a combination of ploughing, trenching and post lay burial via jetting.

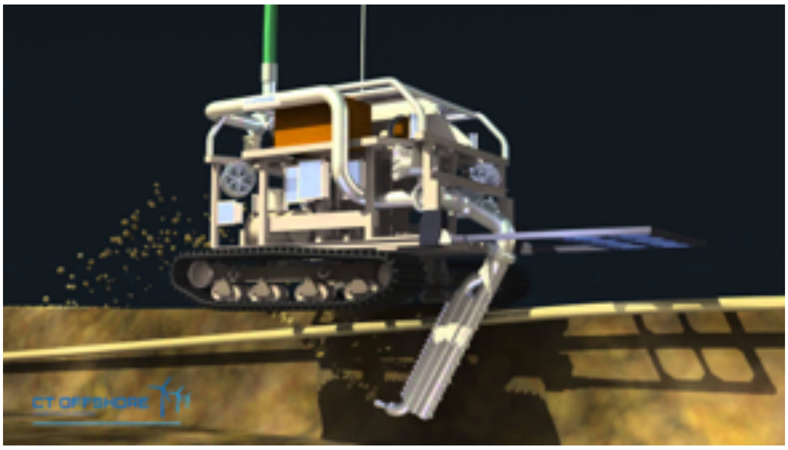
Burial via ploughing can be undertaken concurrently with the laying of the cable and will be used where there is sufficient suitable sediment, such as sandy or silty sediments. The cable is continuously thread through the plough as it is pulled along the seafloor by the cable lay vessel, creating a narrow trench approximately 200 mm wide and up to 2.4 m deep (with a target depth of approximately 1 m). An example of the plough system in operation is shown in **Figure 4-14**. Where ploughing is unable to be undertaken, a ROV will bury the cable using jetting techniques (**Figure 4-15**).

Routine maintenance of the cable is not expected following installation. However, in the unlikely event of damage or failure of the cable, relevant authorities and stakeholders will be consulted. Should they be required, repair of the cable will likely involve lifting the cable to the sea surface by a specialised vessel.

As mentioned above, the forward approvals process for the installation and connection of the cable is subject to financial and commercial arrangements, and the timing of other customer negotiations and connections. Activity specific secondary approvals will be obtained in accordance with regulatory requirements at the time once commercial arrangements are agreed.

(source: Kis-Orca 2017)

Figure 4-14: Example plough



(source: CT Offshore 2017)

Figure 4-15: Example of ROV jetting technique

4.3.4 Decommissioning

The project will be decommissioned at the end of its operating life when production from the gas reservoirs is no longer economically viable. The overarching objective of decommissioning will be to ensure that activities do not cause unacceptable environmental impacts and are the most appropriate for the circumstances at the time in which decommissioning is undertaken.

The project will be decommissioned in accordance with prevailing legislation at the time, and taking into account industry learnings given the future decommissioning activities that are anticipated over the intervening period. Currently, this is governed by the OPGGS Act, which requires regulatory acceptance of an EP that includes decommissioning activities and Safety Case prior to activities commencing.

The OPGGS Act (Section 572(3)) outlines that a titleholder must remove *"all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations".* However, this obligation is subject to other provisions of the Act and allows titleholders to make alternative arrangements for the treatment of equipment (e.g. partial removal or abandonment in situ) through the submission of an EP that includes decommissioning activities, provided that these arrangements ensure that impacts and risk are acceptable and ALARP (NOPSEMA 2015b).

Consideration may also be given to the requirements of the *Environmental Protection (Sea Dumping) Act 1981*, which is administered by DoEE, or future contemporary legislative requirements at the time, should any equipment be proposed to be left on the seabed.

Decommissioning activities within the Barossa offshore development area may last in the order of five years. On completion of decommissioning, ConocoPhillips will apply to relinquish the Barossa offshore development area production and infrastructure licences.

Prior to decommissioning, an EP will be submitted to NOPSEMA for acceptance after considering a range of decommissioning options, including but not limited to those outlined below for project infrastructure, and will present an ALARP assessment of the appropriate strategy at that time:

- plugging and abandonment of production wells
- infield infrastructure (e.g. risers, umbilicals, PLET, manifold, jacket/foundation, moorings, anchors, chain) – options may include removal and onshore disposal, leave in-situ, jacket toppling, or offshore deepwater disposal
- pipelines, flowlines and fibre optic cable – options may include total removal, leave in-situ, or partial removal
- disconnection and offsite decommissioning of the FPSO facility.

It is widely accepted that in selecting the "best" decommissioning option, it is essential that due consideration is given to the critical inter-related requirements of human health and safety, environmental protection, technological feasibility, local capacity, regulatory compliance and economic stewardship within the broader context of public participation and acceptability.

An ALARP assessment of the above decommissioning options will provide transparency in decision making where environmental benefits and impacts are clearly presented in the context of a broader framework of decision criteria.

Considering that the project is in the early design phase, and given the expected life of the project is approximately 25 years, it is premature to define a decommissioning strategy that aims to address environmental impacts in detail in this OPP. While key decommissioning risks have been broadly addressed (refer to **Sections 6.4.2, 6.4.5** and **Table 7.1**), the activity-specific decommissioning EP will provide detailed information and descriptions of the nature and scale of the activity, potential environmental impacts and risks, and the control measures that will be implemented. As such, this OPP only outlines broad EPOs relating to this future activity, as aligned with the intent for this to be an 'early stage, whole-of-project' assessment.

4.3.5 Key aspects associated with the project

Key aspects associated with the project (i.e. elements of the project activities that can interact with the environment) are described in **Section 4.3.5.1** to **Section 4.3.5.10** below.

4.3.5.1 Physical presence of offshore facilities/infrastructure, equipment and project related vessel movements

The physical presence of the project will consist of the FPSO facility, in-field subsea infrastructure and the gas export pipeline, as described in **Section 4.3.3**. A number of vessels will also be present, predominantly in the Barossa offshore development area, throughout the life of the project (**Table 4-5**). These offshore facilities/infrastructure and equipment will be present both at the sea surface (e.g. FPSO facility and project vessels), within the water column (e.g. FPSO facility mooring lines and flexible risers) and on the seabed (e.g. flowlines, umbilicals, manifolds and the gas export pipeline).

The seabed footprint associated with these project facilities/infrastructure and equipment, and the area disturbed, is considered separately within this OPP, as outlined in **Section 4.3.5.2**.

A number of vessels will be required throughout the project. **Table 4-5** provides an indicative summary of the vessel types and activities that will be undertaken throughout the project. The highest frequency of vessel movements (types and numbers) are expected to occur during installation. However, given the life of operations (approximately 25 years), as compared to the short term duration for the installation phase, total vessel movements will be greater during the operations phase. It is expected that approximately two to five vessels will enter/exit the Barossa offshore development area per week during operations, with peak numbers occurring during maintenance and shutdown periods. Although a number of different vessel types will be used in the Barossa offshore development area during operations (**Table 4-5**), not all will be in the field simultaneously. During gas export pipeline installation, not all vessels types listed in **Table 4-5** may be used for pipelay activities as their use will be determined by the installation method selected (**Section 4.3.3.2**). In-field vessels operating within the Barossa offshore development area and gas export pipeline corridor will typically travel at speeds slower than those operating in offshore waters, and therefore exhibit a lower risk profile in terms of collisions.

Table 4-5: Summary of indicative vessel types and activities

Vessel type	Key project stage					
	Development drilling	Tow-out and hook up of the FPSO facility	Subsea installation (including in-field infrastructure and gas export pipeline)	Pre-commissioning and commissioning	Operations	Decommissioning
Heavy lift vessel		✓	✓	✓	✓	✓
Infield support vessel		✓		✓	✓	✓
Offshore support vessel (e.g. MODU/ drill ship support vessel, well testing vessel, inspection, monitoring, maintenance and repair vessel)	✓	✓		✓	✓	✓
Survey vessel and chase vessel			✓		✓	
Anchor handling tug	✓	✓	✓			✓
Accommodation and support vessel		✓	✓	✓	✓	
Installation vessel			✓			
Hook-up vessel			✓			
Derrick barge		✓				
Pipelay vessel			✓			
Pipelay supply vessel			✓			
Line pipe supply vessels (e.g. barges, tugs, general cargo vessels and/ or dynamically positioned supply vessels)			✓			
Seabed intervention vessels (e.g. rock fall pipe vessel, rock side dump vessel, trenching/dredging vessels)			✓			
Cable lay vessel			✓			
Diver support vessel		✓	✓	✓	✓	✓
Post-lay trenching vessel			✓			
ROV inspection vessel	✓	✓	✓	✓	✓	✓
Offtake tankers					✓	

4.3.5.2 Seabed disturbance

Permanent and/or long-term seabed disturbance will occur due to direct placement of subsea infrastructure on the seabed, anchoring, installation of moorings, and seabed intervention works and laying of the gas export pipeline.

Based on the project activities (as described in **Section 4.3.1** to **Section 4.3.4**), early engineering designs and known standard sizes of subsea infrastructure, the total area of direct physical seabed disturbance is expected to be in the order of approximately 1.07 square kilometres (km^2) or 107 hectare (ha). This total area comprises the MODU moorings, FPSO facility mooring, in-field infrastructure (Barossa Field and Caldita Field), gas export pipeline (including seabed intervention techniques from physical infrastructure and physical placement of any excavated materials directly on the seabed (refer to **Section 4.4.3**)) and fibre optic cable. While it is unlikely that vessels would routinely anchor within the Barossa offshore development area, anchoring may be required for heavy lift operations during installation and for the accommodation vessel. During pipline installation, routine anchoring is not expected unless the final pipeline route remains outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor **(Figure 4-12)**. The use of an anchored pipelay vessel may be required within this 30 km section only (refer to **Section 4.3.5.3** for a description of vessels). Any direct seabed disturbance associated with anchoring of vessels has been accounted for in the total area of 107 ha. Localised seabed disturbance could also occur as a result of unplanned dropped objects.

At this early stage, disturbance associated with localised lateral movement or scouring of the gas export pipeline, is expected to only occur in cyclonic and storm events. It is anticipated, as seen with other pipelines in the region, the pipeline will become partially buried which provides further stabilisation in storm events. For the purpose of this early stage OPP assessment, it is assumed that direct disturbance will be limited and within design specifications that accommodate lateral movement. Optimisation work will be undertaken as the engineering design progresses to understand how the gas export pipeline behaves under 10 year and 100 year storm conditions.

The actual area of direct seabed disturbance may change based on further refinement of the design concept, particularly in relation to the proposed tie-in of the gas export pipeline to the existing Bayu-Undan to Darwin pipeline. An assessment of seabed disturbance is provided in **Section 6.4.3**. Seabed disturbance will also be assessed, and associated impacts and risks to the marine environment further evaluated, in activity-specific EPs.

Indirect and temporary seabed disturbance may occur as a result of sedimentation and turbidity generated from activities associated with the controlled placement of infrastructure on the seabed or from seabed intervention techniques used during installation of the gas export pipeline. Seabed intervention techniques may include pre-and post-lay stabilisation measures ranging from concrete mattresses, sand/grout bags and steel structures for free span-rectification, rock bolting and gravity anchors, to secondary stabilisation techniques such as trenching/dredging or rock dumping (refer to **Section 4.4.3** for a description of the alternative gas export pipeline laying methods and seabed intervention techniques). In addition, the planned discharge of drilling cuttings and fluids is a routine part of drilling operations. Refer to **Section 6.4.3** and **Section 6.4.8.2** for a detailed assessment of seabed disturbance, including disturbance associated with drilling fluids and cuttings.

4.3.5.3 Underwater noise emissions

The key source of underwater noise emissions will be associated with the operation of the FPSO facility and project vessels during installation and operations. As outlined above the presence of vessels within the project area, and noise generating activities such as pile driving, will be greatest during the installation phase of the project. However, these activities are temporary and short term in nature. During the operating phase for the project there will be fewer noise generating sources, but these will occur over the life of the project, such as the presence of the FPSO facility and periodic offtake of hydrocarbons by export tankers.

Helicopters will be used to transport personnel between Darwin and the Barossa offshore development area and have the potential to result in localised underwater noise emissions when landing on the MODU/drill ship or FPSO facility. It is anticipated that up to four helicopter transfer flights each week will be required from the MODU/drill rig during development drilling and six helicopter transfer flights each week FPSO facility during normal operations. In times of high activity during operations, such as crew changes, shutdowns and major maintenance, it is anticipated that there could be two to three flights per day to and from the FPSO facility.

Piles or anchors are the typical methods used to secure mooring lines for FPSO facilities or any other supporting infrastructure associated with offshore projects. As detailed in **Section 4.4.3**, pile driving may be required to secure the piles, which can result in higher levels of underwater noise compared to the use of suction piles or anchors. A preliminary assessment of pile driving has been incorporated into this OPP in relation to underwater noise emissions (**Section 6.4.5**). If future planned geotechnical investigations of the seabed in the Barossa offshore development area indicate that pile driving will be required, ConocoPhillips will undertake a detailed impact assessment to determine if the implementation of additional noise management controls are needed. The risk assessment and outcomes will be detailed in the activity-specific EPs that will be submitted to NOPSEMA for acceptance.

4.3.5.4 Invasive marine species (biosecurity)

Vessels, facilities (including MODUs/drill ships) and equipment sourced from outside Australia have the potential to introduce or transport invasive marine species (IMS) to the project area. IMS or non-indigenous species are marine fauna or flora that have been introduced into an area beyond their natural geographical range, and may have the ability to survive, reproduce and establish a population such that they threaten native species through increased competition for resources and/or increased predation.

The project will be managed in accordance with a Quarantine Management Plan and all relevant Australian and international regulations, requirements and guidelines. Refer to **Section 6.4.4** for discussion of the management of IMS and biosecurity risks.

4.3.5.5 Atmospheric emissions

Atmospheric emissions associated with the project will be generated by a number of key sources:

- combustion emissions from power generation and compression
- periodic flaring of gas during development drilling and commissioning (e.g. well clean-up), start-up and shutdown activities, or during blowdown of the subsea system for safety purposes. There will be a continuous low flow of pilot gas to maintain the flare alight (pilot flame) during planned operation, so that the flare system is always ready for its purpose as an over-pressure safety system.
- CO_2 extraction treatment of the feed gas prior to transport to the DLNG facility through the gas export pipeline
- fugitive emissions
- transportation, such as vessel and helicopter movements.

Atmospheric emissions will include emissions of oxides of nitrogen (NO_x), CO_2, sulphur dioxide (SO_2), carbon monoxide (CO), methane (CH_4), volatile organic compounds and intermittent volumes of particulates in smoke. Atmospheric emissions anticipated under normal project operating conditions are not yet quantified in detail as the specific processing equipment has not been defined. **Section 6.4.6** provides an assessment of a range of typical emissions that will be generated by the project. Key emissions and pollutants will be further defined for future project stages in activity-specific EPs, in which equipment specifications will be further defined.

Greenhouse gases

GHG emissions will occur throughout all stages of the project, with the primary sources being venting of CO_2, fuel gas combustion and unplanned/upset flaring.

The total GHG emissions footprint comprises both native reservoir CO_2, and equipment/processing emissions. Reservoir emissions are proportional to the CO_2 content of the feed gas and, therefore, dependent significantly on the reservoir properties. Equipment/processing emissions are influenced by the energy requirements of processing and the efficiency of the selected processing scheme; energy efficient design and modern engineering practice will be utilised to minimise emissions.

CO_2 is premised to be removed offshore prior to delivery into the gas export pipeline to a level that is compatible with the existing DLNG facilities. There remains an option of adding facilities onshore to do the full scope of CO_2 removal at DLNG, but this is not currently the design premise. The native CO_2 content of the reservoir gas will vary across the field and has been measured to be between 16 mol% and 20 mol%. Current designs have up to 14 mol% CO_2 being released offshore via venting through thermal oxidizer/acid gas flare with the remaining CO_2 removed at DLNG. Based on early reservoir modelling outputs and early engineering designs, this would result in the production of between 1.4 and 2.1 Mtpa of vented CO_2 emissions per year from the FPSO facility.

Additional CO_2 emissions from offshore fuel and other combustion operations (e.g. turbine and flare emissions) could produce between 0.7 Mtpa and 1.7 Mtpa CO_2 emissions. Therefore, total CO_2 emissions from the FPSO facility are likely to be between 2.1 Mtpa and 3.8 Mtpa. The native CO_2 content of the reservoir gas for the project is a higher proportion when compared to other offshore oil and gas developments in the region. For example, the CO_2 content of the PTT Exploration and Production (PTTEP) Australasia Montara gas may be up to 13% (PTTEP Australasia 2011), the Shell Prelude floating LNG (FLNG) development contains on average 9 mol% CO_2 (Shell 2010) while INPEX's Ichthys gas ranges between 8–17% (INPEX 2010). The three reservoirs making up the Woodside Browse FLNG Development contain on average 10 mol% CO_2 (Woodside 2014). In contrast, the reservoir CO_2 content of the Evans Shoal Field is reportedly higher, in the order of 27% (Geoscience Australia 2017).

In addition to CO_2, emissions of CH_4 and nitrous oxide (N_2O) will contribute to the overall net GHG emissions profile during operations.

GHG emissions for the project have been estimated based on the current engineering concept using the *National Greenhouse and Energy Reporting Act 2007* (NGER) emission estimation methodology. NGER Method 1 was applied, using energy conversion and emission factors from the NGER Determination 2008 (updated July 2014). **Table 4-6** provides the factors used to convert fuel and flare rates into carbon dioxide equivalent (CO_2-e) units.

Table 4-6: Energy conversion and emission factors to inform greenhouse emission estimates

Source/fuel	Energy content (gigajoules (GJ)/m³)	CO_2 (kg CO_2-e/GJ)	CH_4 (kg CO_2-e/GJ)	N_2O (kg CO_2-e/GJ)	Reference source
CO_2 venting	Not applicable	1,000.0	0.0	0.0	Not applicable – assumed pure CO_2
Fuel gas – processed natural gas	0.0393	51.4	0.1	0.03	NGER Schedule 1, Part 2.3 – Emissions released from the combustion of gaseous fuels
Flaring – natural gas production and processing	Not applicable	2.7	0.1	0.03	NGER Subdivision 3.3.9.2, Section 3.85 – Method 1 – gas flared from natural gas production and processing

Table 4-7 provides an indicative summary of the GHG emissions expected under normal operating conditions and the total net emissions (CO_2-e) from the project. The total CO_2-e emissions for the Barossa offshore project from the FPSO facility are estimated to be in the order of 3.4 Mtpa (within the range of 2.1 Mtpa to 3.8 Mtpa outlined previously), which is comparable to other similar offshore gas developments. For example, the Shell Prelude development is estimated to have a CO_2-e of 2.3 Mtpa (Shell 2010), INPEX Ichthys project a CO_2-e of 7 Mtpa (INPEX 2010) and Woodside's Browse FLNG development a CO_2-e of 8.8 Mtpa (Woodside 2014). While the basis for which these emissions inventories are derived is invariably subject to assumptions made by each individual proponent, and also influenced by the source feed gas CO_2 content, this provides a broad indication of the GHG emissions relative to comparable developments based on published data. The emissions for this project have been derived using latest published emission factors as per the NGER methodology, for consistency.

The CO_2-e emissions presented in **Table 4-7** are for the Barossa offshore project, as subject to this OPP process. It is noted that the emissions for the downstream LNG processing at the existing Darwin LNG facility are separately regulated under the licensing for that operational facility. Under current licensing arrangements, total GHG emissions (as CO_2-e) for that facility are licensed at a limit of 2.051 Mtpa for the current LNG operations (NT EPA, 2017). The downstream emissions specific to Darwin LNG includes operational emissions from process boilers, gas incineration, flaring and venting, compressor turbines and power generation. Any future change to emissions associated with Darwin LNG will be addressed, with regard to the Environment Protection Licence and continued operational environmental management of that facility at the time. The full range of potential GHG emission sources and emission profiles will be assessed and defined as the engineering design progresses and these will be detailed in the activity-specific EPs.

Table 4-7: Summary of estimated GHG emissions per annum under normal operating conditions

GHG	Average approximate emissions (tCO_2-e)			
	CO_2 removal	Fuel gas	Flaring	Total
Total CO_2-e	1,821,000	1,509,000	55,000	3,385,000

4.3.5.6 Light emissions

All offshore facilities and project related vessels will be constantly lit to meet operational safety and navigational lighting requirements, as specified by safety case assessments under the OPGGS Act and relevant legislation, such as the *Navigation Act 2012*. Lighting of the FPSO facility will also consider international guidelines such as the International Association of Marine Aids Navigation and Lighthouse Authorities (IALA) Recommendation O-139 on The Marking of Man-Made Offshore Structures.

Light emissions associated with the project are expected to be highest primarily during commissioning, start-up, well clean-up and upset conditions (due to flaring). Under normal operations, the pilot flare for the FPSO facility is not expected to be brighter than normal operational lighting. Light emissions from non-routing/upset flare events will be intermittent and varied in duration. Refer to **Section 6.4.7** for discussion of potential impacts from light emissions generated by the project.

4.3.5.7 Planned discharges

A number of planned discharges will be released to the marine environment throughout the life of the project. The key discharge streams are discussed in further detail below, with potential impacts assessed in detail in **Section 6.4.8**. The discussion of the discharge streams of cooling water, brine and wastewater are focused on the FPSO facility. However, it is expected that similar discharge streams will occur from the MODU/drill ship, vessels and Caldita WHP (wastewater only), albeit at smaller volumes and for less time. The full range of potential planned discharge sources that may be associated with the different stages of the project (e.g. inspection, monitoring, maintenance and repair during operations and decommissioning) will be assessed and defined as the engineering design progresses and detailed in activity-specific EPs.

Produced water

PW refers to water recovered with hydrocarbons from the reservoir on to the FPSO facility. It may contain a mixture of dissolved and dispersed hydrocarbons, dissolved inorganic salts, metals present as dissolved mineral salts and dissolved gases (particularly hydrogen sulphide and CO_2) from the geological formations.

PW will be cooled via the topsides processing and treated to remove oil-in-water concentration to an average of 30 milligrams per litre (mg/L) over any 24-hour period, prior to being discharged to sea at around 60°C. PW will contain low residual concentrations of a small number of process chemicals when discharged, such as corrosion inhibitors, scale, wax, hydrate inhibitors, MEG, methanol, demulsifiers and biocides.

PW will be discharged after treatment to the marine environment during well clean-up/testing activities associated with development drilling and throughout operations on a continuous basis.

The volumes of PW are anticipated to be lowest at the start of production and increase towards the end of the field life-cycle. Minimum and maximum discharge volumes of PW are expected in the order of approximately 1,590 m^3 per day to 3,260 m^3 per day respectively and have a salinity of approximately 15 parts per thousand (ppt). PW will be discharged below the sea surface to assist in rapid dispersion and dilution. Based on the understanding of the reservoir fluids, the PW is expected to contain low concentrations of mercury. Assessment of the PW discharge stream has been undertaken for this OPP (**Section 6.4.8.4**), with a management and monitoring framework defined in **Section 7**.

Cooling water

Cooling water is used to regulate temperature in facility systems and machinery engines, and generally involves a once-through circuit, where ambient seawater is drawn in from seawater intakes, passed through the system and discharged as a thermal waste stream (approximately up to 45°C) into the marine environment. To avoid biofouling of the pipe work and heat exchangers, continuous dosing with biocides (e.g. hypochlorite) is undertaken, leaving a residual concentration in the discharged water. Cooling water will be discharged below the sea surface to assist in rapid dispersion and dilution.

Cooling water discharges from the FPSO facility during operations are expected to be in the order of approximately 360,576 m^3 per day based on maximum flow rates. Chlorine levels in cooling water discharges will be less than or equal to 3 ppm at the point of discharge.

Wastewater (sewage, greywater, bilge and deck drainage)

The MODU/drill ship, FPSO facility, vessels and Caldita WHP (only during infrequent routine maintenance activities; **Section 4.3.1**) will discharge wastewater, consisting of sewage, greywater, bilge and deck drainage from open, un-contaminated drainage areas to the marine environment.

All wastewater discharges will be managed in accordance with the project Waste Management Plan and requirements as detailed in activity-specific EPs. All liquid waste streams generated by vessels will be managed and disposed of in accordance with relevant regulations – most notably the *International Convention for the Prevention of Pollution from Ships 1973*, as modified by the Protocol of 1978 (MARPOL 73/78) and Australian Marine Orders and relevant to vessel class.

The volume of wastewater generated by the FPSO facility during commissioning and operation has been estimated to be in the order of 96 m^3 and 45 m^3 per day, respectively. The treated wastewater is expected to contain constituents such as oil/grease (within discharge limits), suspended solids and coliform bacteria.

Potable water

Potable, demineralised water will be generated using reverse osmosis (RO) units which treat seawater. Potable water is supplied primarily to areas associated with accommodation and domestic services. However, it is also supplied for other purposes such as engine diesel expansion tanks, emergency generator room, the eyewash, safety shower and utilities water systems on deck.

Water produced from the RO units that is unsuitable for consumption (i.e. with a high saline or calcium content) will be redirected for treatment and discharged overboard. Desalination brine is expected to have a slightly elevated salinity of approximately 30% (45 ppt–50 ppt) higher than seawater (approximately 34 ppt).

The volume of the brine discharge is dependent on the requirement for fresh (or potable) water. While the RO units are not yet designed, offshore brine discharges during normal operations are expected to be in the order of 4 m^3 per hour (96 m^3 per day) from the FPSO facility (INPEX 2016; Northern Oil and Gas Australia 2017).

Dewatering of flooding fluid

The subsea flowlines, risers, spools and connections, and gas export pipeline will be filled with flooding fluid during installation, to maintain their integrity, and will need to be dewatered. The vast majority of the dewatering will be associated with the gas export pipeline, which will be discharged at the FPSO facility end of the export pipeline (i.e. at the FPSO facility riser base manifold within the Barossa offshore development area) at the seabed.

The flooding fluid to be dewatered will consist of filtered inhibited seawater containing residual chemicals, which may include MEG, TEG, biocides, corrosion inhibitor, scale inhibitor, dye, fresh water (for salt removal) and oxygen scavengers. The use of chemicals is required to condition the in-field subsea equipment/ infrastructure and gas export pipeline during pre-commissioning and commissioning to clean, preserve and prepare the infrastructure for the introduction of hydrocarbons. Chemicals are also required to avoid internal corrosion and prevent bacterial growth and the accumulation of scale on internal surfaces. The temperature of the flooding fluid discharges will be similar to the surrounding seawater temperature as the subsea equipment is submerged.

The total volume of fluids to be discharged from the gas export pipeline and in-field flowlines during the installation phase, based on current field layout, is in the order of approximately 107,500 m^3–145,000 m^3. The dewatering of the gas export pipeline is expected to account for approximately 96,710 m^3 of the total volume. Dewatering of the spool between the gas export pipeline and the tie-in will be undertaken separately and require the release of water volumes in the order of approximately 30 m^3.

Hydrotest water

Hydrostatic testing will be conducted to assess the structural integrity of pipelines, flowlines, risers, spools and connections. The vast majority of the hydrotest water discharge is associated with testing of the gas export pipeline, which will be discharged at the sea surface at either the FPSO facility end of the export pipeline (i.e. within the Barossa offshore development area) or at the Bayu-Undan pipeline tie-in end of the export pipeline. The topside facilities associated with the FPSO facility will be hydrotested in the fabrication yard to ensure structural integrity and, therefore, there will be no hydrotest discharge in-field anticipated for those facility components.

Hydrotest water will consist of filtered inhibited seawater containing residual chemicals, which may include MEG, TEG, biocides, corrosion inhibitor, scale inhibitor, dye and oxygen scavengers. As outlined above, the use of chemicals is needed to ensure the condition and integrity of the subsea equipment/infrastructure and gas export pipeline is maintained and preserved for operations. The characteristics of the hydrotest water, including the concentrations of the chemicals and temperature, are expected to be very similar to the flooding fluid released during dewatering (as described above).

The total volume of water to be discharged following hydrotesting of the gas export pipeline and in-field flowlines, based on current field layout, will be significantly smaller than that discharged during dewatering and is expected to be in the order of approximately 3,000 m^3, with a maximum single discharge of nominally 1,300 m^3 in any one event.

Chemical assessment process

The selection of chemical products routinely discharged to the marine environment will follow a chemical assessment process. All chemicals assessed and approved for discharge to the marine environment during the project will be listed in a chemical register that will be updated and maintained as new chemicals are required for use.

Assessment and subsequent approval of chemical products is based on potential environmental hazards, intended use (and technical justification for its usage), quantity required and the management controls proposed.

All approved chemicals (hazardous and non-hazardous) will have an environmental risk rating assigned to them, based on the intended use and information supplied in the Chemical Approval Application Form and material safety data sheet (MSDS).

The United Kingdom Offshore Chemical Notification Scheme (OCNS) will be taken into consideration when assigning the environmental risk rating of key chemical products that may be discharged to the marine environment. The Chemical Hazard and Risk Management (CHARM) model, under the OCNS, is the primary tool for ranking offshore chemicals based on assessment of toxicity, biodegradation and bioaccumulation data provided by the chemical supplier. Products not applicable to the CHARM model are assigned an OCNS grouping, which is determined by that substance having the worst case OCNS ranking scheme assignment in terms of biodegradability and bioaccumulative criteria.

Products that meet at least one of the following environmental criteria are considered suitable by ConocoPhillips for use and controlled discharged to the marine environment is permitted:

- rated as Gold or Silver under OCNS CHARM model
- if not rated under the CHARM model, have an OCNS group rating of D or E (i.e. are considered inherently biodegradable and non-bioaccumulative).

The use of products that do not meet these criteria will only be considered following assessment and approval through a chemical assessment process, as outlined above. The assessment will also be informed by an environmental risk assessment which will help ensure that any potential environmental impacts resulting from chemical use and discharge are minimised.

4.3.5.8 Waste management

Hazardous and non-hazardous solid wastes (except sewage and putrescible waste, and drilling cuttings and fluids discharged directly to the seabed) and recyclable materials will be removed from the MODU/drill ship, FPSO facility and vessels and returned to shore for recycling and/or disposal.

All non-hazardous and hazardous solid waste will be managed in accordance with the project Waste Management Plan, and as detailed in activity-specific EPs.

4.3.5.9 Unplanned discharges

As with all offshore oil and gas development projects, there is an inherent risk that unplanned discharges to the marine environment may occur during the project. Unplanned hydrocarbon and chemical releases are not expected to occur during planned activities undertaken for development drilling, installation, operations or decommissioning. These unplanned releases instead represent low probability events that are generally associated with accidental or unanticipated events, such as equipment failure, wet buckling during pipeline installation, vessel collisions (particularly with errant third party vessels) or emergency conditions. Refer to in **Section 6.4.10** for detailed discussion of the unlikely spill scenarios, and the potential impacts and risks.

The project will implement a comprehensive suite of management controls to mitigate the risk and potential impacts associated with the unlikely event of an unplanned discharge to the marine environment, including elimination controls (wherever possible), engineering controls, planned maintenance, operational procedures and spill response measures. These controls are detailed in **Section 6.4.10**.

4.3.6 Summary of key aspects associated with the project

A summary of the interaction between the key project stages (and activities) and aspects that are anticipated to occur is provided in **Table 4-8**. A schematic of the key emissions and discharges associated with the FPSO facility are shown in **Figure 4-16**.

Table 4-8: Key project stages (and activities) and aspects summary

Aspect		Location	Key project stage: Development drilling	Subsea installation (including pipelay)	Tow-out and hook up of the FPSO facility	Pre-commissioning and commissioning	Operations	Decommissioning
Physical presence of offshore facilities/infrastructure, equipment and project related vessel movements		MODU/drill ship; FPSO facility; vessels; in-field subsea infrastructure; export pipeline infrastructure	✓	✓	✓	✓	✓	✓
Seabed disturbance		MODU/drill ship; FPSO facility; vessels; in-field subsea infrastructure; export pipeline infrastructure	✓	✓	✓	✓	✓	✓
Biosecurity (IMS)		MODU/drill ship; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
Underwater noise emissions		MODU/drill ship; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
Atmospheric emissions		MODU/drill ship; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
Light emissions		MODU/drill ship; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
Planned discharges*	Drilling fluids and cuttings	MODU/drill ship	✓					
	BOP hydraulic fluids	MODU/drill ship	✓					
	Cementing fluids	MODU/drill ship	✓					
	Well completion fluids	MODU/drill ship	✓					
	PW	MODU/drill ship; FPSO facility	✓				✓	✓
	Cooling water	MODU/drill ship; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
	Brine	MODU/drill ship; FPSO facility; vessels	✓	✓		✓	✓	
	Dewatering of flooding fluid	In-field pipelines/flowlines and gas export pipeline		✓		✓	✓	
	Hydrotest water	In-field pipelines/flowlines and gas export pipeline		✓		✓	✓	
	Wastewater (sewage, grey-water, bilge and deck drainage)	MODU/drill ship; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
Waste management	Waste management (non-hazardous and hazardous)	MODU/drill ship; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
Unplanned discharges	Hydrocarbon and chemical spills	MODU/drill ship; development well; FPSO facility; vessels	✓	✓	✓	✓	✓	✓
	Wet buckle contingency	Gas export pipeline		✓				

* Note the key discharges associated with the project have been provided, to inform the primary impacts and risks of relevance. Other minor sources of discharges will be addressed in detail in the activity-specific EPs.

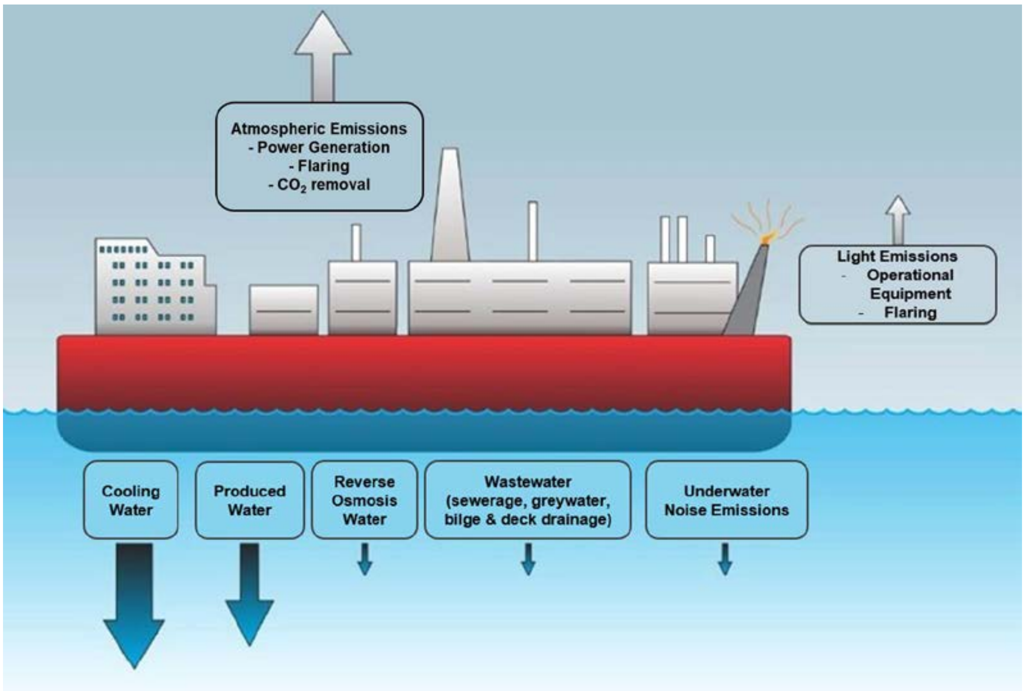


Figure 4-16: Key emissions and discharges associated with the FPSO facility during operations

4.4 Assessment of alternatives

ConocoPhillips evaluated a number of alternative development concepts, including the 'no development' option. The concept evaluation process is iterative throughout the project development process.

4.4.1 Alternative development concepts

Alternative development options were subject to evaluation against a range of criteria, to inform the technical and commercial feasibility of a preferred development concept, including:

- technical feasibility and safety
- environmental – impacts and risks to the marine environment from all project activities, opportunities to reduce impacts and overall environmental footprint, and assessment of environmental acceptability
- social and heritage – benefits and risks, stakeholder and community relations, and potential impacts (positive and negative)
- commercial – financial viability and investibility to secure the capital funding necessary to develop the project and secure necessary customers
- legal requirements and permitting – ability to meet legal requirements and satisfy requirements to obtain timely approvals
- sustainability – consideration of sustainable development principles, whole-of-project considerations, and maximising energy and material efficiencies.

The alternative development concepts considered included:

- DLNG backfill development – new offshore floating facility (FPSO) and gas export pipeline tied into the existing Bayu-Undan to Darwin gas export pipeline to existing onshore liquefaction facilities at DLNG
- DLNG backfill development – new fixed jacket facility and gas export pipeline tied into the existing Bayu-Undan export pipeline to existing onshore liquefaction facilities at DLNG
- new greenfield LNG development – new FLNG facility, with integrated in-field hydrocarbon processing and gas liquefaction and export of LNG direct from offshore.

The evaluation of options was supported by a Sustainable Development (SD) Scorecard, a tool used by ConocoPhillips to facilitate consideration of SD principles to inform early planning and design. The SD Scorecard requires consideration of a number of elements, including the availability of cleaner energy sources, operating to the highest safety standard, impacts to communities and stakeholders, minimising environmental impact, energy efficiency and waste minimisation and ensuring long-term financial viability of the company.

Early screening of the development concepts determined that, of the three options described above, two development concepts (FPSO facility and jacket facility) were commercially viable options that warranted more detailed evaluation, which is provided below. The FLNG option was deemed uneconomic early in the project development phase. The viability of FLNG is dependent on reservoir size, and a number of technical and commercial considerations. Taking into account the field development economics, opportunity to utilise existing infrastructure (i.e. tie-in to Bayu-Undan to Darwin gas export pipeline and DLNG facility) in preference to greenfield development, and the imperative for the project to provide replacement gas for DLNG backfill as the most appropriate gas route to market, FLNG was screened out as a viable option for the project. The construction of new liquefaction facilities needed with the FLNG option added multiple billions of dollars to the development compared with the two viable development options (FPSO facility and jacket facility) that provide the opportunity to utilise existing infrastructure in preference to greenfield development.

The remaining two potential development concepts, an FSPO facility and an offshore fixed jacket facility, were subjected to a rigorous and detailed evaluation. The evaluation concluded that the FPSO facility concept was determined to be a more feasible alternative compared to the fixed jacket facility concept, for the following key reasons:

- HSE – the FPSO facility concept has a number of HSE advantages (due to size and shape), specifically hazardous areas separation and explosion overpressure exposure. It presents the least risk to personnel from (offshore) installation, hook-up and commissioning activities as the majority of these activities will be completed onshore in a shipyard. The FPSO facility concept also has lower production blowout, vessel collision and dropped object risks. The seabed footprint associated with the FPSO concept is expected to be slightly less when compared to the fixed jacket concept taking into account the multiple offshore facilities (central processing facility (CPF), floating storage and offloading (FSO) and WHP) required to support a fixed facility. Therefore, there is a reduced environmental risk and/or safety risk.
- Drilling – the FPSO facility concept has a significantly lower drilling execution risk (therefore, the risk of a long-term well blowout is reduced) as it is much more adaptable to changes in target well locations, which may eventuate from ongoing appraisal activities and studies, due to the flexibility of subsea well placement.
- Operations – the FPSO facility concept will have a larger general liquid storage capacity, which allows a larger degree of operational flexibility in terms of chemical volumes, slops tank capacity and offloading frequency. While this may increase the potential volume of hydrocarbons/chemicals released to the marine environment in the unlikely event of a maximum credible spill scenario (**Section 6.4.10**), the vessel collision risk is reduced. There is a higher probability of a collision for the fixed option as the overall field development is made up of a number of facilities, which increases the size of potential shipping interaction. The FPSO will be permanently moored however will be able to weather vane, limiting the potential target size.
- Schedule and commercial – the FPSO facility concept will deliver first gas approximately 12–18 months earlier than the fixed jacket facility concept, which has significant time and cost saving implications. It also has a significantly lower capital expenditure cost compared to the fixed jacket which improves the commercial viability of the project.

Following the evaluation of various potential development options, the FPSO facility with gas export pipeline was considered the preferred concept to be carried into the next phase of engineering studies, including environmental acceptability, technical feasibility, safety, commercial viability and ConocoPhillips' objectives for sustainable and environmentally responsible development.

The FPSO facility concept provides gas supply continuity for the DLNG facility which has a significant socio-economic benefit to the Darwin community. Further context is provided in **Section 4.4.2**.

A comparative analysis of development themes, encompassing the key concepts assessed to date, and associated environmental impacts and risks relative to the FPSO facility concept proposed in this OPP, is presented in **Table 4-9**. Although the FLNG facility concept was discounted early in the screening process, a comparative analysis has been included for completeness.

Table 4-9: Assessment of development concept alternatives

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
Physical presence of offshore facilities/ infrastructure and equipment and project related vessel movements Seabed disturbance	FPSO facility and gas export pipeline	*Physical presence* FPSO facility and chain mooring system, in-field subsea infrastructure (flowlines, umbilicals, manifolds, wellheads and risers) in the Barossa offshore development area. Gas export pipeline from the Barossa offshore development area to tie-in to the existing Bayu-Undan to Darwin gas export pipeline to transfer gas for processing at the DLNG facility. *Vessel movements* Drilling, installation and supply vessels related to the initial development of the Barossa offshore development area. Condensate shuttle tanker for export from the offshore facility during operations. Installation and maintenance vessels for the gas export pipeline.	*Physical presence* The risk and potential environmental impact from the physical presence of offshore facilities/infrastructure and equipment is low due to: • The Barossa offshore development area, within which the FPSO facility will be located, is approximately 27 km from the nearest shoals/banks. • The Barossa offshore development area is not located in any known regionally important feeding, breeding/nesting or migration areas for marine fauna, including MNES. • The total area of direct physical seabed disturbance associated with the FPSO facility mooring, in-field infrastructure and gas export pipeline is expected to be in the order of approximately 1.07 km^2. • Areas of potentially impacted seabed in the Barossa offshore development area are in deep water, support low diverse/abundant benthic communities, and are well represented in the region. Although the KEF of the shelf break and slope of the Arafura Shelf is mapped as occurring within the Barossa offshore development area, benthic habitat studies have not observed the unique features which define this KEF. Loss or disturbance of habitat in the Barossa offshore development area represents a very small portion of the widespread available habitat in the Timor Sea. • The seafloor features characteristic of the carbonate bank and terrace system of the Van Diemen Rise KEF are likely to occur in the southern end of the gas export pipeline. Loss or disturbance to these seafloor features as a result of the gas export pipeline represents a very small portion (< 0.0002%) of the KEF. • The southern end of the gas export pipeline corridor crosses the internesting habitat critical to the survival of flatback and olive ridley turtles. However, the physical presence of the pipeline is considered highly unlikely to impact the species' use of the area considering its location on the seabed and that the area affected represents only a small portion of the internesting habitat for these species (in the order of approximately < 0.0001% for flatback turtles and approximately < 0.0015% for olive ridley turtles). Installation of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles as part of the forward process of project planning and execution. • While the broad gas export pipeline corridor overlaps the Oceanic Shoals marine park (approximately 1%), the area of direct disturbance from the linear pipeline is estimated to be approximately < 0.0002% of the overall marine park. • The location of the offshore facilities/infrastructure and equipment in the Barossa offshore development area does not represent a significant portion of the area commercially fished, with primary fishing effort of the Timor Reef Fishery undertaken to the south-west. • The gas export pipeline corridor passes through a number of commercial fishing areas with potential for interaction during installation of the pipeline, which is expected to take in the order of six months. • Temporary petroleum safety zone around the drill rig (500 m radius during development drilling) and pipelay vessels (500 m during installation), and exclusion zone around the offshore facilities (in the order of approximately 500 m to 1 km around the FPSO facility) in the Barossa offshore development area will exclude commercial fishing vessels from a small proportion of their current fishing and available areas.	The FPSO facility is the preferred development concept due to: • Technical – demonstrated feasibility of a mature gas processing option with well-defined engineering and safety controls to minimise risks for offshore infrastructure and related vessel movements. • Environmental – areas of seabed at potential risk of environmental impact are well represented in the wider region. Seasonal presence/activity of marine fauna will be taken into consideration as part of the forward project planning for installation of the gas export pipeline. • Social and heritage – low risk of impact on – commercial fishing during operations, and utilisation of existing infrastructure (tie-in to existing Bayu-Darwin gas export pipeline and DLNG facility) removes the need for new greenfield development of onshore gas processing facilities with associated social and heritage values. The majority of the project is also located well away from main shipping routes. • Schedule and commercial – viable development concept to provide the only commercially viable gas route to market.

<table>
<tr><th>Aspect</th><th>Development concept</th><th>Description</th><th>Environmental impact and risk description (relative to FPSO development concept)</th><th>Summary of assessment against key evaluation criteria</th></tr>
<tr><td></td><td></td><td></td><td>Vessel movements
The risk of environmental impact from vessel movements is low due to:
• Little interaction with other vessels as the Barossa offshore development area is located away from commercial shipping routes.
• The potential for interaction with other vessels along the gas export route is slightly higher given the proximity of the southern end of the pipeline to Darwin Harbour and commercial shipping routes.
• Movements inside the Barossa offshore development area are not within any regionally important feeding, breeding/nesting and migration areas for marine fauna, including MNES.
• Vessels installing/commissioning the gas export pipeline will be moving at very low speeds and therefore allow marine fauna, particularly flatback turtles within the biologically important internesting area in the vicinity of the Tiwi Islands, adequate time to dive or move away. Installation of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles as part of the forward process of project planning and execution.</td><td>• Legal requirements and permitting – concept is characterised to inform all legal requirements for permitting.
• Sustainability – concept evaluated in accordance with SD Scorecard to meet SD principles throughout project planning and execution.</td></tr>
<tr><td></td><td>Offshore fixed jacket facility and gas export pipeline</td><td>Physical presence
CPF and gravity based mooring system, FSO facility and gravity based mooring system, satellite wellhead jacket facility (i.e. WHP) and foundations, in-field subsea infrastructure (flowlines, umbilicals, manifolds, wellheads and risers) in the Barossa offshore development area.
Gas export pipeline from the Barossa offshore development area to tie-in to the existing Bayu-Undan to Darwin gas export pipeline to transfer gas for processing at the DLNG facility.
Vessel movements
Drilling, installation and supply vessels related to the initial development of the Barossa offshore development area.
Condensate shuttle tanker for export from the offshore facility during operations.
Installation and maintenance vessels for the gas export pipeline.</td><td>Physical presence
• The risks and potential environmental impacts associated with the offshore fixed jacket facility from the physical presence of offshore facilities/infrastructure and equipment are comparable to the FPSO development concept given the same locational context of the offshore marine environment.
• The seabed footprint in the Barossa offshore development area associated with this concept is slightly greater due to the multiple offshore facilities (CPF, FSO and WHP) and the requirement for subsea infrastructure to connect these facilities.
• The spatial extent of this concept is greater when compared to the FPSO and therefore there is the potential for additional risk of interaction with other users such as commercial fishing.
• Multiple exclusion zones would be required around the various offshore facilities, which would extend the area of exclusion for other marine users.
• The proposed gas export pipeline route would not vary from the FPSO concept.
Vessel movements
• The risks and potential environmental impacts associated with the offshore fixed jacket facility from vessel movements are similar to the FPSO facility development concept.
• More vessels may be required during the installation period due to the greater number of offshore structures, therefore the risk of vessel collisions is higher.</td><td></td></tr>
</table>

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
	FLNG facility	*Physical presence* FLNG facility and turret mooring systems, wellheads, flowlines located in the Barossa offshore development area. DLNG facility would not be backfilled. *Vessel movements* Drilling, installation and supply vessels related to the initial development of the Barossa offshore development area. LNG tanker for export from the offshore facility during operations. Condensate shuttle tanker for export from the offshore facility during operations.	*Physical presence* • The FLNG facility concept has comparable risks and potential environmental impacts from the physical presence of offshore facilities/infrastructure and equipment in the offshore development area when compared to FPSO development concept. However, a FLNG facility has limited onshore/nearshore environmental or social risks with the absence of a connecting pipeline. • There is no significant difference in terms of the seabed footprint in the Barossa offshore development area, however there is no requirement for a gas export pipeline. • The FLNG facility concept would negate the need for gas from the Barossa offshore development area to be delivered onshore to DLNG, which would risk the continuation of socio-economic benefits that DLNG provides into the local NT community. *Vessel movements* • Comparable risks and potential environmental impacts from vessel movements, however lower risk profile during installation given the absence of a gas export pipeline. There would be no risk to commercial fishing activities from the temporary petroleum safety zones during installation of the gas export pipeline. The risk of vessel collisions would also be reduced. • It is expected that the maintenance consumables and personnel and equipment currently going to and from DLNG would need to go offshore in support of a FLNG concept. This may result in increased support vessels going to and from the FLNG facility. • There is no significant difference in terms of vessels requirements for installation, commissioning and operations in the Barossa offshore development area.	

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
IMS (biosecurity)	FPSO facility and gas export pipeline	Movements and ballast water exchange from MODU/drill ship, vessels and FPSO facility.	The risk of environmental impact from invasive marine species is low due to: • The Barossa offshore development area is located in deep waters (130 m–350 m) away from shoals/banks, reefs and nearshore coastal waters. • Vessels installing the gas export pipeline will only be in close proximity to shoals/banks for relatively short periods of time (in the order of weeks to several months), with established biosecurity controls to be implemented to further manage this risk • No tanker movements entering nearshore waters during planned operations. • However, the likelihood of IMS being introduced is considered highly unlikely given the comprehensive key management controls that will be implemented throughout the life of the project and relatively short duration of the gas export pipeline installation program.	The FPSO facility is the preferred development concept due to: • Technical – well-defined controls and processes to minimise risks. • Environmental – majority of the project is in deep waters, representing low risk of introduction and establishment of IMS. • Social and heritage – limited interaction with social and heritage values as relevant to IMS, with well established biosecurity controls to be implemented for project vessels. • Schedule and commercial – viable development concept to provide the most appropriate gas route to market. • Legal requirements and permitting – concept is characterised to inform all legal requirements and guidelines. • Sustainability – concept evaluated in accordance with SD Scorecard to meet SD principles throughout project planning and execution.
	Offshore fixed jacket facility and gas export pipeline	Movements and ballast water exchange from MODU/drill ship, vessels, FSO facility and CPF.	• The risks and potential environmental impacts associated with the offshore fixed jacket facility from IMS are similar to the FPSO facility development concept. There are no additional risks of environmental impact.	
	FLNG facility	Movements and ballast water exchange from MODU/drill ship, vessels and FLNG facility.	• Comparable potential environmental impacts and risks from invasive marine species during operations. However, the lower risk profiling during installation, given the absence of a gas export pipeline, is offset by higher vessel movement during operations to support maintenance.	

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
Underwater noise emissions	FPSO facility and gas export pipeline	Drilling of development wells, including VSP (8–12 hours per well). Installation and commissioning activities, including installation of FPSO moorings and gas export pipeline. Vessel and helicopter movements. Operation of the FPSO facility. Condensate shuttle tankers.	The risk of environmental impact from noise emissions is low due to: • Low risk associated with minor behavioural impacts on marine mammals (particularly pygmy blue whales and Bryde's whales), marine reptiles (turtles and sea snakes), sharks, rays and fish from underwater noise emissions during operations due to distance of FPSO facility and associated vessel movements (e.g. support vessels, condensate shuttle tankers) from important habitat (e.g. shoals/ banks) and biologically important areas (BIAs)/habitat critical to the survival of the species. • Underwater noise emissions in the Barossa offshore development area do not extend into the closest AMP; the Oceanic Shoals marine park. • Low risk associated with temporary and localised effects on seabirds, specifically migratory bird species, from helicopter movements. • Low risk of significant impacts to flatback and olive ridley turtles within the internesting habitat critical to the survival of these species during installation of the gas export pipeline given the reasonably short duration (in the order of 6–12 months), with the key noise sources being either almost stationary (i.e. seabed intervention) or travelling at slow speeds therefore allowing sufficient time for individuals to move away. The noise emissions will also affect only a small portion of the internesting habitat critical to the survival of these species, and seasonal considerations in the scheduling of the pipeline installation activities will minimise project-related noise.	The FPSO facility is the preferred development concept due to: • Technical – well-defined engineering controls to minimise risks, for example, the FPSO facility will be moored so the continuous use of thrusters is not required. • Environmental – operational underwater noise emissions result in a risk of localised impacts, seasonal considerations for marine fauna will be taken into account during installation of the gas export pipeline. • Social and heritage – low risk of impact on commercial fishing during operations. • Schedule and commercial – viable development concept to provide the most appropriate gas route to market. • Legal requirements and permitting – concept is characterised to inform all legal requirements and guidelines. • Sustainability – concept evaluated in accordance with SD Scorecard to meet SD principles throughout project planning and execution.
	Offshore fixed jacket facility and gas export pipeline	Drilling of development wells, including VSP (8–12 hours per well). Installation and commissioning activities, including installation of FSO, CPF and WHP moorings/ footings and gas export pipeline. Vessel and helicopter movements. Operation of the FSO facility and CPF. Condensate shuttle tankers.	• The risks and potential environmental impacts associated with the offshore fixed jacket facility from noise emissions are similar to the FPSO facility development concept. There are no additional risks of environmental impact.	
	FLNG facility	Drilling of development wells, including VSP (8–12 hours per well). Installation and commissioning activities. Vessel and helicopter movements. Operation of the FLNG facility. LNG carriers and condensate shuttle tankers.	• Fewer risks and potential environmental impacts from noise emissions. The lower risk profile is associated with the absence of gas export pipelay activities between the Barossa offshore development area and the Bayu-Undan to Darwin gas export pipeline tie-in. • The FLNG facility is likely to have a slightly larger underwater noise footprint in the Barossa offshore development area given its larger size and greater numbers of sub-surface processing equipment. There is also the contribution of noise from LNG offloading tankers and increased vessel movements for maintenance that would not exist for an FPSO facility/fixed platform concept.	

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
Atmospheric emissions	FPSO facility and gas export pipeline	MODU/drill ship, installation vessels and support vessels during drilling and installation. FPSO facility, support vessels and condensate shuttle tankers during operations.	The risk of environmental impact from atmospheric emissions is low due to: • Low risk of environmental impact to regional air quality from air emissions associated with the FPSO facility and support vessels. • Air emissions from the FPSO facility will be offshore and well-removed from residential or sensitive populations on the Tiwi Islands and NT coast. • Measures will be incorporated into project design to achieve energy efficient operations to minimise GHG emissions where practicable.	The development concepts are broadly comparable in terms of overall atmospheric emissions, with the primary difference being the location of release. No major determining factors between concepts
	Offshore fixed jacket facility and gas export pipeline	MODU/drill ship, installation vessels and support vessels during drilling and installation. FSO facility, CPF, WHP, support vessels and condensate shuttle tankers during operations	• Atmospheric emissions are likely to be slightly higher given the additional infrastructure/facilities and requirement for vessel movements between these.	
	FLNG facility	• MODU/drill ship, installation vessels and support vessels during drilling and installation. • FLNG facility, LNG carriers and condensate shuttle tankers and support vessels during operations.	• Atmospheric emissions from a FLNG facility will be slightly higher as it requires more power to support processing and liquefication facilities.	
Light emissions	Offshore fixed jacket facility and gas export pipeline	Functional and navigational lighting for FPSO facility, CPF and WHP, MODU/drill ship and vessels during installation and operation. Flaring from MODU/drill ship and FPSO facility during drilling, installation and operations.	• Light emissions will be slightly greater given the additional infrastructure/facilities of the CPF and WHP that would require lighting for safety and operational reasons.	The FPSO facility is the preferred development concept due to: • Technical – well-defined engineering controls to minimise risks, while still maintaining safe operations and working conditions.

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
	Offshore fixed jacket facility and gas export pipeline	Functional and navigational lighting for FPSO facility, CPF and WHP, MODU/drill ship and vessels during installation and operation. Flaring from MODU/drill ship and FPSO facility during drilling, installation and operations.	• Light emissions will be slightly greater given the additional infrastructure/facilities of the CPF and WHP that would require lighting for safety and operational reasons.	• Environmental – operational light emissions result in a risk of localised and minor impacts to marine fauna transiting through deep open ocean waters, seasonal considerations for marine fauna will be taken into account during installation of the gas export pipeline. • Social and heritage – low risk of impact on commercial fishing during operations, light emitted during operations will not be visible from coastal residential populations. • Schedule and commercial – viable development concept to provide the most appropriate gas route to market. • Legal requirements and permitting – concept is characterised to inform all legal requirements and guidelines. • Sustainability – concept evaluated in accordance with SD Scorecard to meet ESD principles throughout project planning and execution.
	FLNG facility	Functional and navigational lighting for FLNG facility, MODU/drill ship and vessels during installation and operation. Flaring from MODU/drill ship and FLNG facility during drilling, installation and operations.	• Lower risk profile given the absence of gas export pipelay activities between the Barossa offshore development area and the Bayu-Undan to Darwin gas export pipeline tie-in. • Light emissions from the FLNG facility are likely to be greater given its large size.	
Planned discharges Waste management	FPSO facility and gas export pipeline	FPSO facility and vessels during all phases of the project.	The risk of environmental impact from planned discharges and waste management is low due to: • Drill cuttings and fluids routinely released during development drilling will be discharged away from sensitive benthic habitat, such as shoals/banks, and are not predicted to contact these features. • Planned PW and cooling water discharges will be in open offshore waters and result in localised impacts. Given the large-scale currents and mixing, the discharge plumes are expected to rapidly dilute and therefore will not contact the closest shoals/banks. Marine fauna, including EPBC listed marine mammals, turtles, sea snakes, fish and sharks are not expected to be significantly impacted as the Barossa offshore development area does not contain any significant feeding, breeding or aggregation areas for marine fauna species.	The FPSO facility is the preferred development concept due to: • Technical – well-defined engineering controls (including routine monitoring) to minimise risks.

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
	FPSO facility and gas export pipeline	FPSO facility and vessels during all phases of the project.	• Planned wastewater discharge is characterised by low volumes. • No planned offshore disposal of solid waste generated on the FPSO facility or vessels.	• Environmental – operational discharges occur in deep waters away from shoals/banks and significant feeding, breeding or aggregation areas for marine fauna. • Social and heritage – low risk of impact on commercial fishing during operations. • Schedule and commercial – viable development concept to provide the most appropriate gas route to market. • Legal requirements and permitting – concept is characterised to inform all legal requirements. • Sustainability – concept evaluated in accordance with SD Scorecard to meet ESD principles throughout project planning and execution.
	Offshore fixed jacket facility and gas export pipeline	FSO facility, CPF and vessels during all phases of the project.	• The risks and potential environmental impacts associated with the offshore fixed jacket facility from planned discharges and waste management are similar to FPSO facility development concept.	
	FLNG facility	FLNG facility and vessels during all phases of the project.	• Given larger size of the processing and storage facilities onboard the FLNG facility cooling water requirements would be higher, and therefore larger volumes of cooling water would be discharged to the marine environment. • Planned discharges from vessels associated with the installation of a gas export pipeline are not relevant to this concept, however discharges and wastes associated with other project-related support vessels remain as per the other development concepts	
Unplanned discharges	FPSO facility and gas export pipeline	Drilling of development wells. Vessel collision during installation activities in the Barossa offshore development area or along the gas export pipeline. Transfer, handling, storage or use of chemicals on FPSO facility and vessels. Use and/or production and storage of hydrocarbons on FPSO facility. Offtake from the FPSO facility.	The risk of environmental impact from unplanned discharges is medium due to: • Potential for significant environmental impacts from a long-term well blowout during development drilling. However, the likelihood of this occurring is considered very low with the implementation of a comprehensive set of management controls (**Section 6.4.10**). • Any small spills are not expected to contact shoals/banks, reefs, islands or the open waters of the AMPs. • Environmental impacts may occur in the unlikely event of a large-scale release in the Barossa offshore development area or gas export pipeline, depending on the nature and scale of the release. A comprehensive range of controls have been defined to manage this risk over the life of the project.	All of the development concepts have the potential to result in impacts to the environment in the highly unlikely event of a large-scale release. All concepts are broadly comparable in terms of the area of influence, given the largest area of potential impact is associated with a long-term well blowout.

Aspect	Development concept	Description	Environmental impact and risk description (relative to FPSO development concept)	Summary of assessment against key evaluation criteria
	Offshore fixed jacket facility and gas export pipeline	Drilling of development wells. Vessel collision during installation activities in the Barossa offshore development area or along the gas export pipeline. Transfer, handling, storage or use of chemicals on FSO facility, CPF, WHP and vessels. Use and/or production and storage of hydrocarbons on FPSO facility. Offtake from the FPSO facility.	• There is a slightly higher risk of unplanned releases due to an errant vessel collision as the overall field development is made up of a larger number of facilities.	A comprehensive suite of well-defined engineering controls will be implemented to minimise risks throughout the life of the development. All aspects of the project will be undertaken in accordance with the highest safety standard. Core elements of the management framework to manage the risk of unplanned discharges include: • Maintenance of petroleum safety zones to minimise risk of collisions • Controls for hydrocarbon and chemical storage and bunkering • Comprehensive well design and control activities in accordance with approved regulatory requirements • Spill response preparedness and training, with Incident Management and Response planning, training and audits in place • A comprehensive spill response strategy appropriate to the nature and scale of a potential release, supported by an Operational and Scientific Monitoring Program (OSMP).
	FLNG facility	Drilling of development wells. Transfer, handling, storage or use of chemicals on FLNG facility and vessels. Use and/or production and storage of hydrocarbons on FLNG facility. Offtake from the FLNG facility.	• Given the FLNG facility has larger condensate storage, fuel and chemical storage facilities, the potential release volumes from an unplanned event would be greater, therefore the potential area of influence may be greater assuming the same engineering controls and response arrangements. • No risk of environmental impact from a spill associated with a vessel collision during installation of the gas export pipeline (approximate 6-12 month period).	

4.4.2 'No development' alternative

The existing Bayu-Undan and DLNG projects illustrate the benefits of development. To date this integrated project has paid over US$20 billion in taxes to Australia and Timor-Leste, and currently provides direct employment of over 1,300 people (Chamber 2017). In addition, there are flow-on effects from creation of local jobs and supplier opportunities that have been generated. Delivering gas through the proposed development concept to DLNG will enable these socio-economic benefits to continue.

The project also aligns with the Australian governments' broad mandate to develop offshore oil and gas resources. Specifically, the role of the DIIS in relation to the development of offshore oil and gas resources is to increase investment in petroleum development in offshore areas under Commonwealth jurisdiction. The Department recognises that investment in this area provides benefits to the Australian community through the following:

- energy supply for transport, domestic and industrial uses
- taxation revenues
- employment
- exports
- regional development
- downstream processing
- enhanced energy security.

In addition, to satisfy offshore permit retention lease requirements, ConocoPhillips has an obligation to undertake exploration and develop any commercially viable hydrocarbon reserves. In this context, the 'no development' alternative is not consistent with the legal obligations and commercial objectives of ConocoPhillips and was not considered further.

4.4.3 Design/activity alternatives

Alternative design features and delivery options (methods) were considered for the various project activities, as described in **Section 4.3**, and are discussed below.

Alternative offtake configurations

Offtake configurations can vary depending upon the FPSO facility station-keeping method, environmental conditions and design factors. The most common FPSO facility/offtake tanker offtake configurations include tandem, side-by-side and remote buoy mooring systems. In a tandem offtake configuration, the tanker is positioned at a safe distance and moored by the bow to the FPSO facility. The tanker maintains position with the assistance of a holdback tug. During side-by-side offtake, the FPSO facility and tanker are positioned adjacent to each other in a parallel orientation. In buoy-based mooring systems, an offtake pipeline is extended from the FPSO facility to a moored buoy station at a distant location, and this provides a fixed offtake point for tankers.

A tandem offtake configuration was selected for the project as it allows the greatest flexibility in operations and has the lowest environmental risk of the alternative options available. For example, there is a lower risk of a collision occurring between the FPSO facility and the tanker in a tandem offtake configuration when compared with a side-by-side configuration. The buoy-based mooring system would require additional disturbance to the seabed for the installation of mooring lines and anchors and from the additional subsea pipeline connecting the FPSO facility to the buoy. A tandem offtake configuration does not require the installation of any structures on the seabed as the tanker maintains position through use of a holdback tug.

Alternate installation methods for the FPSO facility mooring lines

One of the preferred options of securing the FPSO facility mooring lines to the seabed is by suction piling. The suction piles (indicative size of 8 m–10 m in diameter and 25 m–30 m in length, and weighing approximately 300 tonnes) will be slowly lowered on to the seabed using gravity. The water contained within the piles is then pumped out creating differential pressure which draws the pile deeper into the seabed.

Drag embedment anchors are another preferred alternative and are installed by pulling the anchor across the seafloor for a short distance (approximately 10 m). The fluted shape of the anchor causes it to penetrate and imbed into the seabed as it is pulled forward.

If future planned geotechnical investigations of the seabed at the proposed location of the FPSO facility mooring lines indicate that the seabed is unsuitable for suction piles or drag embedment anchors, pile driving will be required. Options for pile driving include drilling and cementing, or impact or vibratory piling. The drilling and cementing method involves the drilling of a pile borehole using a water based drilling fluid, installation of the pile in the borehole and then the pumping of cement down the pile to displace the drilling fluid from the pile. Impact piling involves the driving of piles into the seabed using a hydraulic hammer that is driven onto the piling element using a ram mass. In vibratory piling, the piles are driven into the seabed using a small longitudinal vibration motion produced by a vibratory hammer, which contains a system of rotating eccentric weights. The weights are arranged such that they allow only vertical vibrations to be transmitted into the pile, thereby reducing ground vibrations and underwater noise emissions.

Alternate development drilling schedule

Subject to schedule requirements and availability, concurrent drilling using two MODUs/drill ships may be considered during development drilling. The drilling method would be identical and therefore the planned emissions and discharges would be duplicated, but for a shorter period. It is expected that the time required for development drilling would likely be halved should two MODUs/drill ships be used.

Additional management controls would be implemented to manage the simultaneous operation of the MODUs/drill ships to ensure no interaction occurs. The MODUs/drill ships will always be separated at least 1 km apart during drilling operations as they will each have a 500 m petroleum safety zone.

Alternative gas export pipeline corridor options

In the version of the OPP that was published for the public comment period (Revision 2), ConocoPhillips presented a broad gas export pipeline corridor (Rev 2 pipeline corridor). This was considered appropriate at the time of the public comment period, given the early stage of engineering design and the requirement for further surveys and studies to better define potential installation routes and therefore, further define a feasible gas export pipeline corridor. The broader Rev 2 pipeline corridor allowed for pipeline installation both within and outside the Oceanic Shoals marine park, as well as allowing further consideration and evaluation of an alternative western pipeline route to tie into the existing Bayu-Undan pipeline (western corridor alignment) and an eastern corridor alignment through the shallow water zone east of the Oceanic Shoals marine park and north-east of the Tiwi Islands (**Figure 4-12**).

During and subsequent to the OPP public comment period, further geophysical and bathymetric surveys have been completed, allowing engineering and design work to be progressed which has informed a refined pipeline corridor. As a result of further engineering, the previously considered alternative western route to tie into the existing Bayu-Undan pipeline has been ruled out as not being technically feasible for the project. Dropping this alternative western pipeline route also has the advantage of minimising the area that the pipeline corridor overlaps the Oceanic Shoals marine park. Additionally, a pipeline corridor that avoids overlapping any of the internesting habitat critical to the survival of the olive ridley turtle (i.e. to the west) has been discounted due to the presence of significant seabed features and highly irregular seabed topography to the west of the Tiwi Islands that could not be avoided by a pipeline route.

Following further evaluation, the eastern corridor alignment through the shallow water zone (**Section 4.3.3.2**) was discounted due to the presence of highly irregular seabed topography and shallow water depths that would require significantly greater seabed intervention, including dredging/trenching activities for secondary stabilisation, thereby resulting in greater environmental impacts.

Consequently, the refined gas export pipeline corridor has been defined and presented in **Figure 4-3**. This refined corridor is the preferred option for the project, as it achieves the following benefits:

- minimises, as much as practicable, areas of seabed within the pipeline corridor that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of the Van Diemen Rise KEFs (see **Section 5.7.8**)
- minimises the area that a pipeline route would need to overlap of the Oceanic Shoals marine park
- minimises the amount of seabed installation and stabilisation required for pipeline installation, and eliminates the requirement for dredging or trenching (if the final route is located within the Oceanic Shoals marine park)
- still allows for an option for the final pipeline route to be located outside (immediately adjacent) of the Oceanic Shoals marine park
- a pipeline route within this corridor will reduce inspection, maintenance and repair (IMR) requirements during operations, compared to all other alternative options considered
- represents the shortest length of pipeline required and shortest installation campaign, thereby minimising the time installation activities will overlap with internesting habitat critical to the survival for marine turtles.

A comparative assessment of the pipeline corridor alternatives considered for the project is presented in **Table 4-10**.

Table 4-10: Assessment of gas export pipeline corridor alternatives

Key considerations	Merit assessment		
	Refined corridor alignment (post public comment period)	Western corridor alignment – outside of internesting habitat critical to survival of olive ridley turtles	Eastern corridor alignment – crossing shallow zone east of the Oceanic Shoals marine park
Technical risk	• Minimises, as much as practicable, areas of seabed within the pipeline corridor that are associated with the seafloor features/values of the KEFs of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of the Van Diemen Rise KEFs. • No significant seabed intervention or secondary stabilisation required if the final pipeline route is located within the Oceanic Shoals marine park (within the pipeline corridor), as the water depth is > 30 m. Secondary stabilisation such as trenching/dredging and/or rock dumping may be required if the final route must remain outside the Oceanic Shoals marine park , i.e. in the shallower water area (< 30 m deep) immediately to the east of the marine park **Figure 4-12**). • If the final route must remain outside the Oceanic Shoals marine park in the shallow water area, an anchored pipelay vessel may be required for this section, as the water depth is < 30 m. An anchored pipelay vessel would not be used for any other sections of the pipeline corridor. • Minimises the number of span rectifications required. Allows for the final pipeline route to be located outside the Oceanic Shoals marine park (if required), in an area of shallow water immediately to the east of the marine park (**Figure 4-3**). While this area was defined from the Fugro (2017) survey as being the least challenging route outside the marine park, in terms of seabed topography, the seabed in this area is still considered highly irregular with significant seabed intervention and secondary stabilisation likely to be required. • Minimises IMR campaigns during operations. • Lowest technical risk for installation and ongoing operation and maintenance.	• Highly irregular seabed topography west of the internesting habitat critical to the survival of olive ridley turtles, which will significantly increase the requirement for seabed intervention works and span rectifications. • Significant gully feature approximately 100 m deep and 4 km long that could not be avoided if the pipeline corridor is aligned to avoid the internesting habitat critical to the survival of olive ridley turtle. • Immediately after crossing the gully there are various locations of water depths < 30 m, not all of which can be avoided. Secondary stabilisation works such as dredging or trenching would be required in these areas. An anchored pipelay vessel may also be required in these areas, increasing seabed disturbance and increasing the length of the pipeline installation campaign in the internesting habitat critical to the survival of flatback turtles. • As a result of further project engineering and design work, a western pipeline route (and hence corridor) to the existing Bayu-Undan pipeline has been ruled out as technically not feasible for the project. This option requires a longer pipeline, larger diameter pipeline, significantly longer pipeline installation campaign and introduces significant technical and operations risk to the project. • Increased technical risk for installation, ongoing operations and maintenance, including additional IMR campaigns during operations.	• Irregular seabed topography, including presence of sandwave features for approximately 23 km, that cannot be avoided if the corridor is situated in this area. • Significant seabed intervention and secondary stabilisation (trenching/dredging) likely to be required for length of the corridor containing sandwaves (approximately 23 km of the corridor alignment) and in water depth less than nominally 30 m. • May require the use of a specialised anchored shallow water barge; resulting in two pipelay vessel spreads being required and additional seabed impacts from pipelay vessel anchoring. • Increased technical risk for installation, ongoing operations and maintenance, including additional IMR campaigns during operations.

<table>
<tr><th rowspan="2">Key considerations</th><th colspan="3">Merit assessment</th></tr>
<tr><th>Refined corridor alignment (post public comment period)</th><th>Western corridor alignment – outside of internesting habitat critical to survival of olive ridley turtles</th><th>Eastern corridor alignment – crossing shallow zone east of the Oceanic Shoals marine park</th></tr>
<tr><td>Environmental impact</td><td>With the exception of the shallow water area immediately east of the Oceanic Shoals marine park, the pipeline corridor is located in water depths > 30 m and an anchored pipelay vessel will not be used.
The pipeline corridor (with the exception of the shallow water area immediately east of the Oceanic Shoals marine park) is located in water depths > 30 m , therefore outside water depths known to be used by internesting turtles resting in the days prior to re-nesting.
If the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, this section of the pipeline corridor does not overlap habitat critical to the survival of olive ridley turtles, but does overlap the habitat critical to the survival of flatback turtles. This overlap only represents 0.15% of the habitat critical to the survival for flatback turtles and the area is greater than 20 km from the Tiwi Islands coastline (Figure 5-18). Additionally, potential internesting habitat < 30 m deep is widespread in the immediate vicinity (Figure 5-18).
If the final route crosses a small portion of the Oceanic Shoals marine park (which will avoid the need for any trenching/dredging), the habitat present in that portion has been identified as containing representative habitat found elsewhere in the marine park (i.e. not unique). Mining activities (including pipeline installation and operation) are allowed under the transitional arrangements governing the current management of the marine park.</td><td>Alignment would avoid internesting habitat critical to the survival of olive ridley turtles, however would still overlap internesting habitat critical to the survival of flatback turtles and given the additional seabed intervention required, would result in a significantly greater impact compared to the impact from installing the pipeline within the internesting habitat critical to the survival for olive ridley turtles.
A final pipeline route in this corridor alignment would not minimise impacts to areas of seabed that are associated with the seafloor features/values of the Van Diemen Rise KEF (e.g. a significant gully and ridge features).
A pipeline route through the western corridor option would likely overlap a greater portion of the Oceanic Shoals marine park and would not minimise impact to the marine park (as requested by Parks Australia) compared to a pipeline route within the refined corridor.
Significantly more seabed intervention likely to be required, including additional span rectifications, removal/ fill of seabed material, placement of rock berm and dredging/trenching for secondary stabilisation.
The increased requirements for seabed intervention and secondary stabilisation are likely to result in an increase in impacts to the ecological function, values and sensitivities of the KEFs and Oceanic Shoals marine park, and increase in indirect impacts within internesting habitat critical to survival for flatback turtles.
An anchored pipelay vessel/barge may be required due to the shallow water depth, as opposed to a dynamically positioned vessel, increasing seabed disturbance.</td><td>Alignment would avoid the Oceanic Shoals marine park, however the pipeline would be required to be installed closer to the high density olive ridley turtle nesting beaches on the north-west of the Tiwi Islands, including water depths known to be utilised by the majority of internesting turtles (i.e. water depths shallower than 30 m).
Significantly more seabed intervention likely to be required, including additional span rectifications, removal/ fill of seabed material, placement of rock berm and dredging/trenching for secondary stabilisation.
The increased requirements for seabed intervention and secondary stabilisation are likely to result in an increase in impacts to the ecological function, values and sensitivities of the KEFs and an increase in indirect impacts within internesting habitat critical to survival for marine turtles.
An anchored pipelay vessel/barge may be required due to the shallow water depth, as opposed to a dynamically positioned vessel, thereby increasing seabed disturbance.
Potential higher impact on nearshore traditional uses of the Tiwi Islanders.</td></tr>
</table>

<table>
<tr><th rowspan="2">Key considerations</th><th colspan="3">Merit assessment</th></tr>
<tr><th>Refined corridor alignment (post public comment period)</th><th>Western corridor alignment – outside of internesting habitat critical to survival of olive ridley turtles</th><th>Eastern corridor alignment – crossing shallow zone east of the Oceanic Shoals marine park</th></tr>
<tr><td></td><td>• Allows for the pipeline to be located further away from the nearest coastal and nearshore features of the Tiwi Islands, including high density olive ridley turtle nesting beaches on the north-west coast of the Tiwi Islands.
• Minimises, as much as practicable, impacts to areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of the Van Diemen Rise KEFs. Therefore, reduces potential impacts to the ecological function, values and sensitivities of the KEFs.
• While some span rectification is required, local re-routing will be used to reduce this requierment, thereby reducing environmental impacts from rectification works.
• Minimisation of seabed intervention and associated seabed disturbance (direct and indirect impacts).
• Consistent with the Recovery Plan for Marine Turtles in Australia – the corridor represents the shortest feasible route to tieback to the existing Bayu-Undan pipeline whilst also minimising the requirement for seabed intervention and span rectification and avoiding the requirement for secondary stabilisation (dredging or trenching) if the final route crosses a small portion of the Oceanic Shoals marine park. This results in the minimisation of the potential duration that the pipeline installation activities could overlap internesting habitat critical to the survival of marine turtles, whilst also reducing potential indirect impacts. If the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, and if trenching/dredging activities are required, they will not occur during the peak nesting period for olive ridley or flatback turtles. Refer to Section 6 for further demonstration of the project's consistency with the recovery plan.</td><td>• Alignment would avoid the Oceanic Shoals marine park, however the pipeline would be required to be installed closer to the high density olive ridley turtle nesting beaches on
• Unlikely to be consistent with the Recovery Plan for Marine Turtles in Australia – a pipeline route through this area is longer in length and likely to take a longer time to install given the significant seabed intervention and secondary stabilisation works required. Therefore, pipeline installation would likely overlap internesting habitat critical to the survival of marine turtles for a longer period than the refined corridor, with greater potential for indirect impacts. In addition, dredging/trenching activities during peak nesting periods are not considered consistent with the recovery plan, and hence two pipeline installation campaigns may be required.</td><td>• Unlikely to be consistent with the Recovery Pan for Marine Turtles in Australia – a pipeline route through this area is longer in length and likely to take a longer time to install given the significant seabed intervention and secondary stabilisation works required. Therefore, pipeline installation would likely overlap internesting habitat critical to the survival of marine turtles for a longer period than the refined corridor, with greater potential for indirect impacts. In addition, dredging/trenching activities during peak nesting periods are not considered consistent with the recovery plan, and hence two pipeline installation campaigns may be required.</td></tr>
</table>

Key considerations	Merit assessment		
	Refined corridor alignment (post public comment period)	Western corridor alignment – outside of internesting habitat critical to survival of olive ridley turtles	Eastern corridor alignment – crossing shallow zone east of the Oceanic Shoals marine park
Capital cost and schedule	• Shortest feasible route to tie-in to the existing Bayu-Undan pipeline. • Lowest cost of the assessed pipeline corridor options. • A pipeline route within this corridor represents the shortest installation timeframe, due to a combination of being the shortest route with the least seabed intervention requirements. • If the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, there is the potential for two pipeline installation campaigns due to the requirement for secondary stabilisation (trenching/dredging) and the potential for the requirement of an anchored pipelay vessel.	• Increased cost due to high number of spans, seabed intervention and potential for a shallow water pipelay vessel/barge spread. • Potential for two pipeline installation campaigns given the need for dredging/trenching within internesting habitat critical to the survival of marine turtles and potential requirement for an anchored pipelay vessel for sections of the installation works with corresponding increase in impacts and risks associated with vessel based activities.	• Increased cost due to high number of spans, seabed intervention and potential for a shallow water pipelay vessel/barge spread. • Potential for two pipeline installation campaigns given the need for dredging/trenching within internesting habitat critical to the survival of marine turtles and potential requirement for an anchored pipelay vessel for sections of the installation works with corresponding increase in impacts and risks associated with vessel based activities.

Alternate gas export pipeline laying methods and seabed intervention techniques

The gas export pipeline will be laid using a continuous assembly pipe-welding installation method, which involves welding the pipe segments onboard the pipelay vessel. The pipe is then laid onto the seabed using an S-lay method, with the S notation referring to the shape of the pipeline as it is laid onto the seabed. Refer to **Section 4.3.3.2** for further discussion on the installation of the gas export pipeline.

With a pipeline diameter of 24–26-inch, 260 km–290 km length and relatively shallow water depths, the pipeline installation methods of reeling, towing and J-lay can be discounted. The feasibility of reel lay has an upper limit of a pipeline diameter of around 16-inches and may be used for the in-field flowlines. The length of the pipeline segment that can be towed is limited to approximately 4 km to 5 km. If towing were used it would result in a large number of connections which are costly and represent potential leak sources. The water depths along the gas export pipeline corridor make J-lay impractical as it would over stress the pipeline leading to buckling.

The primary method of maintaining pipeline stability on the seabed will be through concrete weight-coating. Where the required stability cannot be achieved through this means alone, a range of seabed intervention techniques (includes pre-lay and post-lay span correction, stabilisation and secondary stabilisation methods) may be used. Stabilisation methods could include, concrete mattresses, sand/grout bags and steel structures for free span-rectification, rock bolting and gravity anchors. Secondary stabilisation such as trenching/dredging or rock dumping may be required in the shallow water area of the pipeline corridor if the final gas export pipeline corridor is located outside of the Oceanic Shoals marine park. These methods, and the potential locations, are described in detail in **Section 4.3.3.2**. The selection of seabed intervention techniques will be further refined in activity-specific EPs and informed by future engineering and geotechnical studies

Horizontal directional drilling will not be required for the gas export pipeline as there is no shore crossing.

Vessel type alternatives

The ConocoPhillips Global Marine Vetting Standard requires the preferential selection of vessels that are carrying ConocoPhillips hydrocarbon liquid, chemical or gas cargoes (e.g. export tankers) to be double hull design to reduce the likelihood of leaks or spills to the marine environment from low-impact collisions, as perforation of both hulls is unlikely. In the event that an exception is required, alternative engineering design considerations will be taken into account in the vessel selection process, such as protection of fuel tanks by ballast tanks or other spaces, segregation or sub-division of tanks to reduce individual tank volumes, and emergency rapid transfer systems which allow rapid pumping of fuel to alternate tanks should integrity be compromised.

PW management alternatives

Reinjection of PW was considered during the early stages of the project design and included review of information obtained from appraisal activities which characterised the structure and composition of geological formations below the seabed in the Barossa Field and surrounds. The information obtained from these appraisal activities did not identify any formations within the area that are suitable, in that they would not discretely contain the reinjected PW.

The volumes of PW are anticipated to be relatively low with minimum and maximum discharge volumes expected in the order of approximately 1,590 m^3 per day and to 3,260 m^3 per day respectively. The rock formation below the gas bearing reservoir has a very low permeability and therefore the only water that will be produced initially is from condensation. Eventually edge water is predicted to migrate to the well bore and hydrocarbon production from the well will drop dramatically. At this point the well will be shut-in resulting in the overall water production from field being relatively low.

GHG (CO_2) emissions management alternatives

A summary of GHG emissions estimated for the project is provided in **Section 4.3.5.6**, with an assessment of potential impacts provided further in **Section 6.4.6**.

An evaluation of alternative options for management of GHG emissions was undertaken as part of early feasibility studies. One of these options was the reinjection of native CO_2 from the offshore facilities.

The geological storage technologies involve storage of CO_2 by trapping the gas in a suitable geological formation.

The practicability of CO_2 reinjection is dependent on a range of key site-specific factors, including:

- location of a suitable deep geological reservoir with characteristics suitable for long-term containment, including:
    - adequate capacity and injectivity
    - a satisfactory sealing caprock or confining unit, and
    - a sufficiently stable geological environment to avoid compromising the integrity of the storage site
- technical engineering and economic considerations of 'source-to-sink' transport of CO_2, including engineering requirements for additional pipeline infrastructure, gas separation facilities and subsea wells
- long-term considerations of the future monitoring and verification of CO_2 trapping, and potential for leaks over time which may undermine the security of permanent containment
- safety, social and environmental considerations for the reinjection scheme.

Basins suitable for CO_2 storage typically have characteristics such as thick accumulations of sediments, permeable rock formations saturated with saline water (saline formations), extensive covers of low porosity rocks (acting as seals) and structural simplicity. Poor CO_2 storage potential is likely to be exhibited by basins that (Intergovernmental Panel on Climate Change 2005):

- are thin (≤1,000 m)
- have poor reservoir and seal relationships
- are highly faulted and fractured
- are within fold belts
- have strongly discordant sequences
- have undergone significant physical and chemical change during or after formation, or
- have overpressured reservoirs.

For potential geological storage capacity to be viable, the storage project must be economically viable, technically feasible, safe, environmentally and socially sustainable and acceptable to the community. Geoscience Australia has been undertaking research into sedimentary basins which have the potential for geological storage, liaising with the State and NT Geological Surveys and other agencies to select acreage for release and to consider other issues associated with CO_2 storage.

As relevant for the project, the nearest operating oil and gas facility is the Bayu-Undan facility located in the Joint Petroleum Development Area (JPDA) of the Timor Sea. The reservoir supporting this facility is located approximately 360 km from the Barossa offshore development area, which would require a subsea trunkline to transport the CO_2. The Bayu-Undan Field is a currently producing gas and condensate field, and for this reason is not currently accessible for geosequestration. The potential for utilising the depleted Bayu-Undan reservoir at some point in the future has been subject to evaluation. Concerns with remoteness of the injection site (additional compression on the Barossa FPSO facility, dedicated pipeline and subsea injection wells, in addition to further line compression at the Bayu-Undan location to be able to achieve the high injection pressures) and the fact that Bayu-Undan lies outside of Australian waters and in the JPDA represented significant uncertainties for use of this location as a geosequestration site. It is concluded that geosequestration is technically challenging, unproven over the long-term and risky, and would render the Barossa development uneconomic and no development option would result.

The capital cost of CO_2 reinjection including offshore compression equipment, significant pipeline infrastructure and subsea wells is expected to be in the order of AU$800 million. This is not considered a reasonably practicable alternative when assessed against both business economic challenges and viable alternatives to offset emissions. Other more viable options are available to achieve the objective of managing GHG emissions, as described in **Section 6**.

Dewatering discharge management alternatives

The subsea flowlines, pipelines and other equipment will be temporarily filled with flooding fluid during the time following installation and pre-commissioning/commissioning. The equipment will need to be filled with inhibited water during this time, and dosed with a sufficient concentration of biocide and oxygen scavenger to ensure integrity is maintained through the required preservation period. The flooding fluid (i.e. inhibited water dosed with biocide and oxygen scavenger) associated with the project is proposed to be discharged (i.e. dewatered) to the marine environment. An alternative discharge method of storing the flooding fluid and transport to onshore facilities for treatment and disposal was considered. However, this option was not considered practicable due to the large volume of water involved (approximately 107,500 m3–145,500 m3 for the gas export pipeline and in-field infrastructure during installation) and the number of vessel movements required.

Reuse of flooding fluid (and hydrotest water) within the in-field flowline systems would require significant engineering design, installation restrictions and system modifications to make this alternative workable. The current subsea architecture is premised on a hub and spoke arrangement where the approach is to water fill all the flowlines from the subsea temporary pig launchers, and then hydrotest prior to the FPSO facility arrival. Once the flowlines are hydrotested the spools connecting the flowlines to the drill centre manifolds and the flexible risers up to the FPSO facility will be installed before the flowline system is dewatered and dried. It should be noted that the flowline end termination structures at the ends of each flowline have no full bore valves and, as such, the flowlines must be flooded to enable tie-in of the flowlines to the FPSO facility and the drill centre manifolds. In order to reuse the flooding fluid (and hydrotest water) within the flowline system the flowlines would need to be flooded, hydrotested, hooked-up and dewatered sequentially, which would considerably increase the complexity of installation activities and their duration; this is not deemed practical. Storage tanks may also be required and would increase the number of vessels in the Barossa offshore development area.

The consideration of only using freshwater was discounted in the early stages of the engineering design as it would be more energy intensive and impracticable to source large volumes of fresh, potable water that could otherwise be used as a valuable community or ecological resource onshore. It should be noted that the use of freshwater does not alleviate the use of biocides and oxygen scavengers and these chemicals are required to ensure the integrity of the flowlines and pipeline is maintained. Furthermore, the use of freshwater creates additional operational challenges due to its lower density compared seawater resulting in raw seawater ingress during tie-in operations.

Caldita Field development concepts

The Caldita Field will be evaluated for development as a subsea tie-back in the future. As the resource size at Caldita is relatively small, development will only proceed if a development plan is economically feasible.

The most likely development would involve a subsea development with a subsea pipeline back to the Barossa FPSO facility. The installation, commissioning and operation of the subsea development would be undertaken in the same manner as the Barossa Field; no additional or new types of activities are proposed and all activities, associated with a Caldita Field development would be within the Barossa offshore development area (**Figure 4-2**).

Alternative development methods, such as installing an unmanned WHP at Caldita, may provide more efficient and economic ways of developing the field. The unmanned WHP would be similar to that at the ConocoPhillips operated Bayu-Undan Field (**Figure 4-17**) and comprise limited processing and utility facilities. Process equipment would likely be limited to well production trees, wellhead manifolds and choke valves to control well flow, and a subsea production flowline(s) connected to the Barossa FPSO facility. No processing or storage of reservoir fluids will occur, and therefore no routine production discharges are expected. Small volumes of wastewater (including sewage) may be discharged when personnel are present to undertake infrequent, routine operational maintenance activities. The WHP will include facilities for a limited number of personnel (approximately 10 persons) to stay overnight if required to support routine maintenance. All planned impacts will be within the Barossa offshore development area and the seabed footprint of the WHP is expected to be approximately 2,500 m^2 (0.25 ha).

Considering the nature of the WHP, the interaction of this facility with the marine environment is limited, with only very small volumes of sewage and wastewater discharged while maintenance activities are undertaken. Given this, and the fact that the activities associated with a future Caldita development (including installation and operation) share the same aspects to those proposed for the broader project concept, all of the relevant environmental impacts and risks as relevant to a future Caldita WHP will be similar and are addressed within the impact and risk evaluation for the full project development concept (**Section 6**). All planned impacts will be within the Barossa offshore development area.

Figure 4-17: Bayu-Undan unmanned wellhead platform

5 Description of the environment

Section 5 summary

Purpose:

This section describes the existing environment of the project area and wider region, including natural features, marine life and habitats, and any other non-oil and gas uses. Understanding the environment and the social, economic, and cultural features of the area helps to assess the potential impacts and risks (further described in **Section 6**) and develop the environmental performance outcomes for the project (further described in **Section 7**).

The OPP considers the environment in the context of the following geographical areas:

1. the **project area**, which consists of:
   - the **Barossa offshore development area** where the facilities and infrastructure will be located and where the marine environment may be affected by planned discharges (**Section 6**)
   - the **gas export pipeline corridor** within which the gas export pipeline route will be located.

   Given the early stage of the project, a buffer has been incorporated into this area. The area directly influenced by the project is expected to be significantly smaller.

2. the area of influence which (based on repeated modelling of the worst credible hydrocarbon spill scenarios) is the outer boundary of the environment that may be affected in the event of an unplanned release of hydrocarbons where no spill response measures are implemented.

Section at a glance:

Barossa marine studies program: ConocoPhillips explains how it developed a detailed understanding of the environment, including in-depth baseline studies that were completed in collaboration with the Australian Institute of Marine Science and scientific experts.

Regional setting: Australia's marine environment is classified into six regions. The North Marine Region is of primary relevance to this OPP being the region containing the Barossa offshore development area and the gas export pipeline corridor. The North-west Marine Region is also relevant as parts of it are within the area of influence.

Physical environment: The studies show that natural features including the climate, seabed, air quality, water currents and temperature, water and sediment quality, and underwater noise in the Barossa offshore development area are all typical of the region.

There are no significant seabed features in the Barossa offshore development area. The closest regionally important environmental features to the Barossa offshore development area are Evans Shoal (35 km west), Tassie Shoal (32 km west) and Lynedoch Bank (27 km east). Three shoals and banks (Goodrich Bank, Marie Shoal and Shepparton Shoal) are of particular relevance to the gas export pipeline corridor. In the area of influence, the most important features are Ashmore Reef (750 km south-west), Cartier Island (735 km south-west), Seringapatam Reef (960 km south-west) and Scott Reef (970 km south-west).

Marine fauna: There are 20 threatened species and 41 migratory species that may occur in the Barossa offshore development area and gas export pipeline corridor. The Barossa offshore development area has no unique or specific habitats for these marine fauna, so while they may pass through, they will not remain here. There is no land or other features that support nesting or feeding turtles, breeding populations of seabirds, or migratory shorebirds. The Tiwi Islands are about 100 km south of the Barossa offshore development area and about 6 km from the gas export pipeline corridor at its closest point. These islands support several important habitats, nesting sites for marine turtles, seabird rookeries and the conservation of dugongs. Further environmental surveys and engineering studies will be incorporated to finalise the pipeline route.

Socio-economic and cultural environment: There are no heritage properties or wetlands, nor ecological communities requiring specific protection measures in the Barossa offshore development area or gas export pipeline corridor. The gas export pipeline corridor traverses a portion of the Oceanic Shoals marine park and the Tiwi Islands hold heritage value for the Indigenous people.

There are a number of fisheries in the region, with five currently active in the project area. Based on consultations to date, ConocoPhillips understand there are no areas of high fishing activity in the vicinity of the project.

Tourism activities such as organised recreational fishing rarely occur in or near the area due to its remote location. These activities are more likely to occur near the southern end of the gas export pipeline, near the Tiwi Islands, where there is also more commercial shipping activity.

5 Description of the environment

5.1 Overview

This section of the OPP describes the key physical, biological, socio-economic and cultural characteristics of the existing environment relevant to the proposal, including MNES as defined under the Commonwealth EPBC Act.

The description of the environment presented in this OPP is considered comprehensive and conservative based on the early stage project definition and optionality. It provides a description of environmental values and sensitivities within two areas:

- the project area, which consists of the Barossa offshore development area and the gas export pipeline corridor (as defined in **Section 4.2.1.1**)
- the potential area of influence associated with the project (as defined below). The potential area of influence will be further refined as future detailed engineering information becomes available and will be presented in the activity-specific EPs.

The description provided in this section has been used to inform the risk evaluation and impact assessment for the project (**Section 6**).

This section aligns with the NOPSEMA OPP Guidance Note (NOPSEMA 2016a): *"To provide information important to the context of the OPP by identifying and describing the existing environment that may be affected by the project"*.

The following key sources of information were used to inform the comprehensive assessment of environmental values and sensitivities in this OPP:

- ConocoPhillips Barossa marine studies program (2014–15), including a collaborative survey of surrounding shoals undertaken by the Australian Institute of Marine Science (AIMS) (**Section 5.2**)
- Environment Plan for the ConocoPhillips Bonaparte Basin Barossa Appraisal Drilling campaign, revision as accepted by NOPSEMA (2013)
- recent Environment Plans for the ConocoPhillips Barossa Appraisal Drilling Campaign and Caldita-Barossa Marine Seismic Survey activities as accepted by NOPSEMA (2016)
- previous ConocoPhillips environmental studies, including pre-drill environmental surveys for the Caldita-1 (URS 2005), Caldita-2 (URS 2008) and Barossa-1 (URS 2007) well locations
- material provided by the DoEE, including EPBC Protected Matters search tool, species profile and threats database, National Conservation Values Atlas biologically important areas (BIAs) and internesting habitat critical to the survival of marine turtles, recovery/management plans and conservation advices (**Section 3.5.1**), bioregional marine region plans, conservation value report cards, threat abatement plans, National strategies, marine park management plans (currently draft), and CMR Review Panel reports
- published Environmental Impact Statement (EIS)/offshore referral study reports to inform the regional environmental context, including:
  - Woodside Energy Limited (Woodside). 2001. Sunrise Gas Project, Draft EIS, EPBC Referral, and EIS supplement (2002)
  - Methanol and Synfuels Pty. Ltd. 2002. Tassie Shoal Methanol Project Draft EIS, EPBC Referral 2000/108
  - GDF Suez Bonaparte. 2011. Bonaparte LNG Supplementary Report, September 2011
  - Woodside. 2011. Browse LNG Development, Draft Upstream EIS EPBC Referral 2008/4111 (November 2011)
  - Woodside. 2013. Floating LNG EPBC referral 2013/7079 (December 2013), Draft EIS (November 2014) and EIS Supplement (May 2015)
  - INPEX. 2010. Ichthys Gas Field Development Project Draft EIS, and subsequent EIS Supplement (April 2011).
- published literature on the regional environmental values and sensitivities, e.g. PTTEP surveys initiated in response to the Montara incident (Heyward et al. 2010; Heyward et al. 2011) and as published on the North West Atlas.
- engagement with recognised experts in specific discipline areas of biological science in the Bonaparte Basin.

Definition of the area of influence in the context of environmental baseline

The area of influence for the project is the outer boundary of the environment that may be affected in the event of an unplanned release of hydrocarbons where no spill response measures are implemented. The outer boundary has been defined using the largest geographic extent of the adverse exposure zone from modelling the worst case credible spill scenarios that could occur during the project (refer to **Section 6.4.10** for a definition of adverse exposure zone). Stochastic modelling was used to derive the largest extent of the adverse exposure zone based on the following three maximum credible spill scenarios:

- entrained hydrocarbons from a loss of well integrity (i.e. long-term well blowout) in the Barossa offshore development area
- surface hydrocarbons from an offtake tanker vessel collision in the Barossa offshore development area
- surface hydrocarbons from a pipelay vessel collision along the gas export pipeline. In the context of the gas export pipeline, a surface release has been used as stochastic modelling did not predict any entrainment of hydrocarbons.

The extent of the environment that may be affected from planned discharges that will occur during the project was informed by discharge modelling studies, as described in **Section 6.4.8**. In general, planned discharges are expected to be diluted below levels of environmental significance within a conservative radius of approximately 21 km from the discharge location in the Barossa offshore development area. Therefore, planned discharges are encompassed within both the project area and the outer boundary of the area of influence defined by the adverse exposure zone for hydrocarbons released from an unplanned spill scenario. No planned discharges are anticipated from the gas export pipeline once it is operational, with the exception of those from vessels undertaking periodic maintenance along the pipeline during operations. However, these discharges will be small, localised and temporary in nature, and therefore expected to be within the boundary of the gas export pipeline corridor.

Consideration of the area of influence, in addition to the project area, has allowed assessment of all environmental values and sensitivities that could potentially be affected by the project (see **Section 6**).

The boundaries of the project area and the area of influence are shown in **Figure 5-1**.

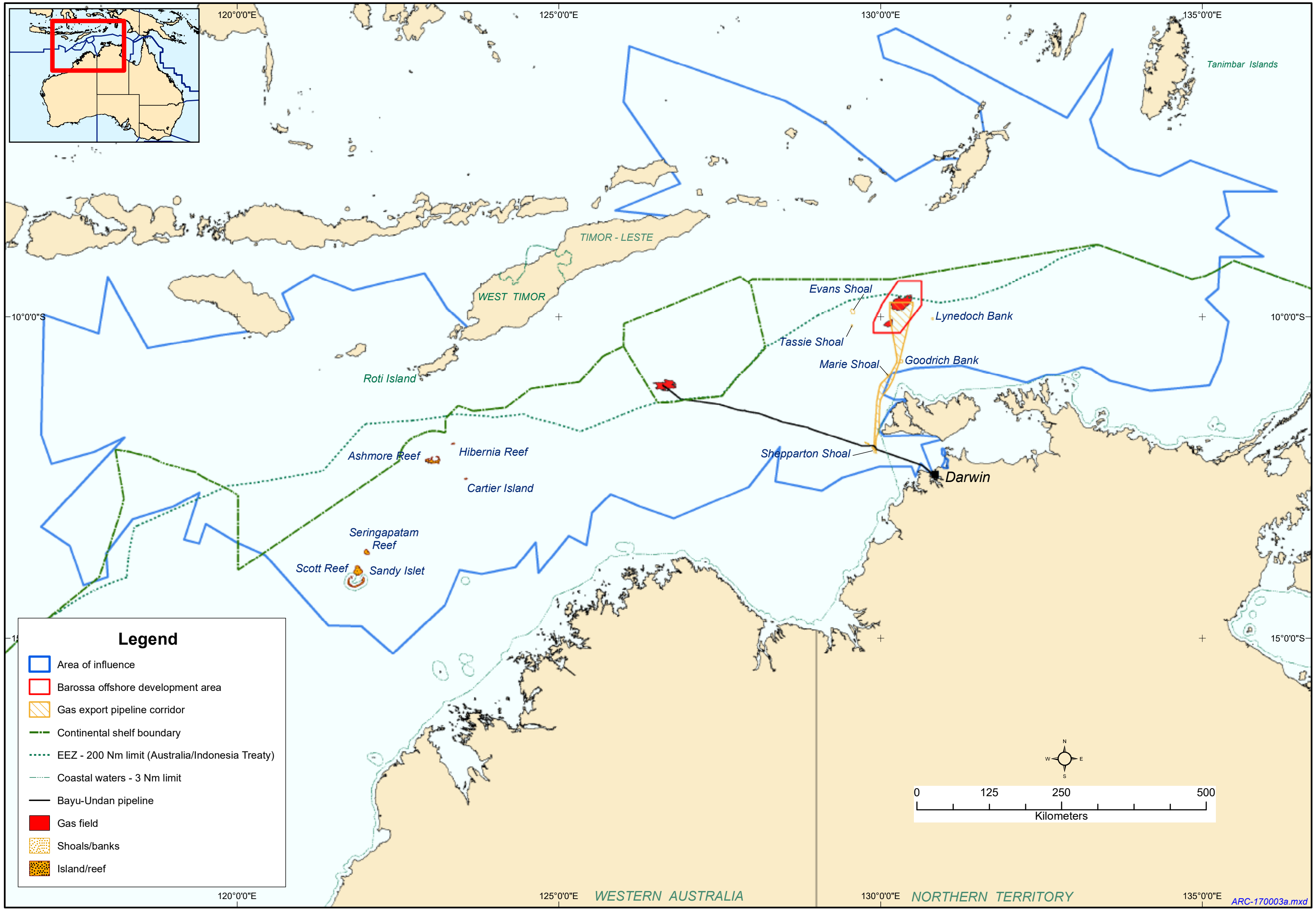


Figure 5-1: Definition of project boundaries in the context of environmental baseline

5.2 Barossa marine studies program

ConocoPhillips has undertaken an extensive and robust environmental baseline studies program, including collaborative studies with the Australian Institute of Marine Science (AIMS), to characterise the existing marine environment within and surrounding the Barossa offshore development area; herein referred to as the Barossa marine studies program. The Barossa marine studies program has involved the collection of detailed baseline data over 12 months (July 2014 to July 2015) in order to capture seasonal variability and to provide focused data to assist in informing the risk assessment of the development options such that they are relevant to the project environmental values and sensitivities (**Figure 5-2**).

In addition to providing specific data and information across the Barossa offshore development area, the studies collected data that have been used to validate the hydrodynamic model developed by RPS Asia-Pacific Applied Science Associates (APASA), which underpins all planned discharge and unplanned spill modelling studies (**Section 6**). Specifically, a hydrodynamic validation study was completed to compare the measured and model-predicted data (winds, waves and currents) to evaluate how accurately the hydrodynamic model could represent actual conditions. The validation study concluded that the model was able to accurately reproduce the conditions across the Barossa offshore development area and surrounding marine environment. This result provides a high level of confidence that the outputs from the planned discharge and unplanned spill modelling (which are based on the hydrodynamic model) are robust and offer an accurate representation of the potential distribution and characteristics of any planned or unplanned discharges relevant to the project.

The Barossa marine studies program undertaken by ConocoPhillips was preceded by early engagement with key agencies and informed by a comprehensive literature review of existing scientific data/studies and gap analysis (JacobsSKM 2014). This process assisted in verifying information that was publicly available and the level of understanding of the marine environment in the Barossa offshore development area and surrounds. This was then used, in conjunction with a review of the relevant project activities, to define the scope and geographical extent of the Barossa marine studies program within the area. The specific location and number of sampling sites was selected to provide a representative assessment of the key characteristics of the Barossa offshore development area, surrounding marine environment, nearest seabed features of significance (Evans Shoal, Tassie Shoal, Lynedoch Bank) and features of interest (i.e. seamounts and scarps). As part of the Australian National Environmental Science Programme, AIMS has subsequently built on regionally collated data with predictive modelling to further characterise the benthic habitats of the Oceanic Shoals marine park and surrounding areas relevant to the gas export pipeline corridor, and this has been incorporated into this assessment.

In addition, the professional views of recognised experts in specific discipline areas were sought via an advisory panel to confirm understanding of values and sensitivities relevant to this OPP. The advisory panel included representatives from the Centre for Whale Research (CWR), Charles Darwin University (CDU), the Department of Biodiversity, Conservation and Attractions (previously Department of Parks and Wildlife (DPaW)) and Monash University.

A summary of the Barossa marine studies program is provided in **Table 5-1** below.

As part of the forward environmental approvals process ConocoPhillips will undertake further targeted surveys of seabed features along the gas export pipeline route as the engineering design progresses, to inform route optimisation. The information from these surveys will further supplement knowledge of the existing marine environment along the proposed route.

Table 5-1: Summary of Barossa marine studies program

Study type	Description of study	Location	Reference (Appendix)
Field-based studies			
Metocean data collection	Collection of metocean data (e.g. current, conductivity, wave and wind data) on the surface and through the water column from July 2014 to March 2015 within and in the vicinity of the Barossa offshore development area (**Figure 5-2**).	Barossa area	Fugro 2015
Water quality survey	Collection of baseline data on physical and chemical components of water quality (**Figure 5-2**). The surveys were completed in June 2014, January 2015 and April 2015.		Jacobs 2016a **(Appendix B)**
Sediment quality and infauna survey	Collection of baseline data on sediment quality and infauna communities.		Jacobs 2016b **(Appendix C)**
Benthic habitat survey	Collection of baseline data to characterise topographic features, benthic habitats and macrofaunal communities, including around Evans Shoal, Tassie Shoal and Lynedoch Bank, through the use of a specialised ROV.		Jacobs 2016c **(Appendix D)**
Underwater noise monitoring survey	Collection of baseline data on ambient underwater noise (physical, biological and anthropogenic sources) at three locations from July 2014 to July 2015.		JASCO Applied Sciences (JASCO) 2016a **(Appendix E)**
Shoals and shelf survey (benthic habitats and fish communities)	A seabed biodiversity survey of three shoals to the west of the Barossa offshore development area (Evans Shoal, Tassie Shoal and Blackwood Shoal1) and two mid-continental shelf regions relevant to the potential gas export pipeline route. The survey was undertaken in September/October 2015 and involved characterisation of the seabed habitats, associated biota and fish communities (shoals only) through the use of multibeam, towed video and stereo baited remote underwater video stations (SBRUVs).	Barossa offshore development area and gas export pipeline, and regional shoals and banks	Heyward et al. 2017 **(Appendix F and Addendum)**
Desktop/modelling studies			
Environmental literature review and gap analysis	Collection and collation of all publicly available information pertaining to the marine environment within the vicinity of the project and gap analysis to determine whether there is sufficient information to inform environmental impact assessment of the project and any future regulatory approvals for a potential development of the Barossa offshore development area.	Regional – Bonaparte Basin	JacobsSKM 2014

Study type	Description of study	Location	Reference (Appendix)
Hydrodynamic model validation study	Data from the metocean study and through the deployment of drifter buoys were used to validate the underlying hydrodynamic model used to develop the spill and discharge models.	Barossa offshore development area	RPS APASA 2015[2]
Drill cuttings dispersion modelling study	To quantify achievable rates of dispersion for drill cuttings and fluids discharges from drilling and to investigate concentrations that could reach key environmental values and sensitivities and under various seasonal conditions.		APASA 2012 **(Appendix G)**
PW discharge modelling study	To quantify achievable rates of dispersion for PW discharges from the FPSO facility and to investigate concentrations that could reach key environmental values and sensitivities under various seasonal conditions.		RPS 2017a (**Appendix H**)
Cooling water discharge modelling study	To understand the change in temperature of cooling water and the dilution of residual chlorine predicted to be released as planned operational discharges from the FPSO facility.		RPS 2017b **(Appendix I)**
Wastewater discharge modelling study	To investigate the seasonal risk and potential exposure from planned wastewater discharges during commissioning and operations, from the FPSO facility.		RPS 2017c **(Appendix J)**
Dewatering discharge modelling study	To quantify the dilution of chemicals within the dewater plume discharged from dewatering of the gas export pipeline, at the FPSO facility end of the pipeline, during commissioning activities.		RPS 2017d **(Appendix K)**
Hydrocarbon spill modelling study	To quantify the transformation and fate of spilled hydrocarbons that would result from an accidental, uncontrolled release from the FPSO facility, subsea infrastructure (e.g. wellhead, manifold, flowline) or vessel activities associated with the subsea pipeline.		RPS 2017e **(Appendix L)**
Toxicity assessment of Barossa condensate	Laboratory based experiments were completed to inform the assessment of species sensitivity to potential toxicity impacts from Barossa condensate.		Jacobs 2017 **(Appendix M)**
Underwater noise modelling study – FPSO facility anchor piling	To quantify probable source levels of underwater noise generated by pile driving activities for the FPSO facility moorings during the construction/installation stage of the project.		JASCO 2017 **(Appendix N)**
Underwater noise modelling study – FPSO facility operations	To quantify probable source levels of underwater noise generated by the FPSO facility during operations and offtake activities.		JASCO 2016b **(Appendix O)**

[1] As the shoals and shelf survey was undertaken as a collaborative study by ConocoPhillips and AIMS, Blackwood Shoal was surveyed as AIMS has a broader interest in understanding the benthic characteristics of shoals in the Timor Sea and this survey represented a timely opportunity to gain further scientific knowledge in this area.

[2] The key results of the hydrodynamic model validation study are incorporated into the planned discharge modelling reports (**Appendix H** to **Appendix K**) and hydrocarbon spill modelling report (**Appendix L**).

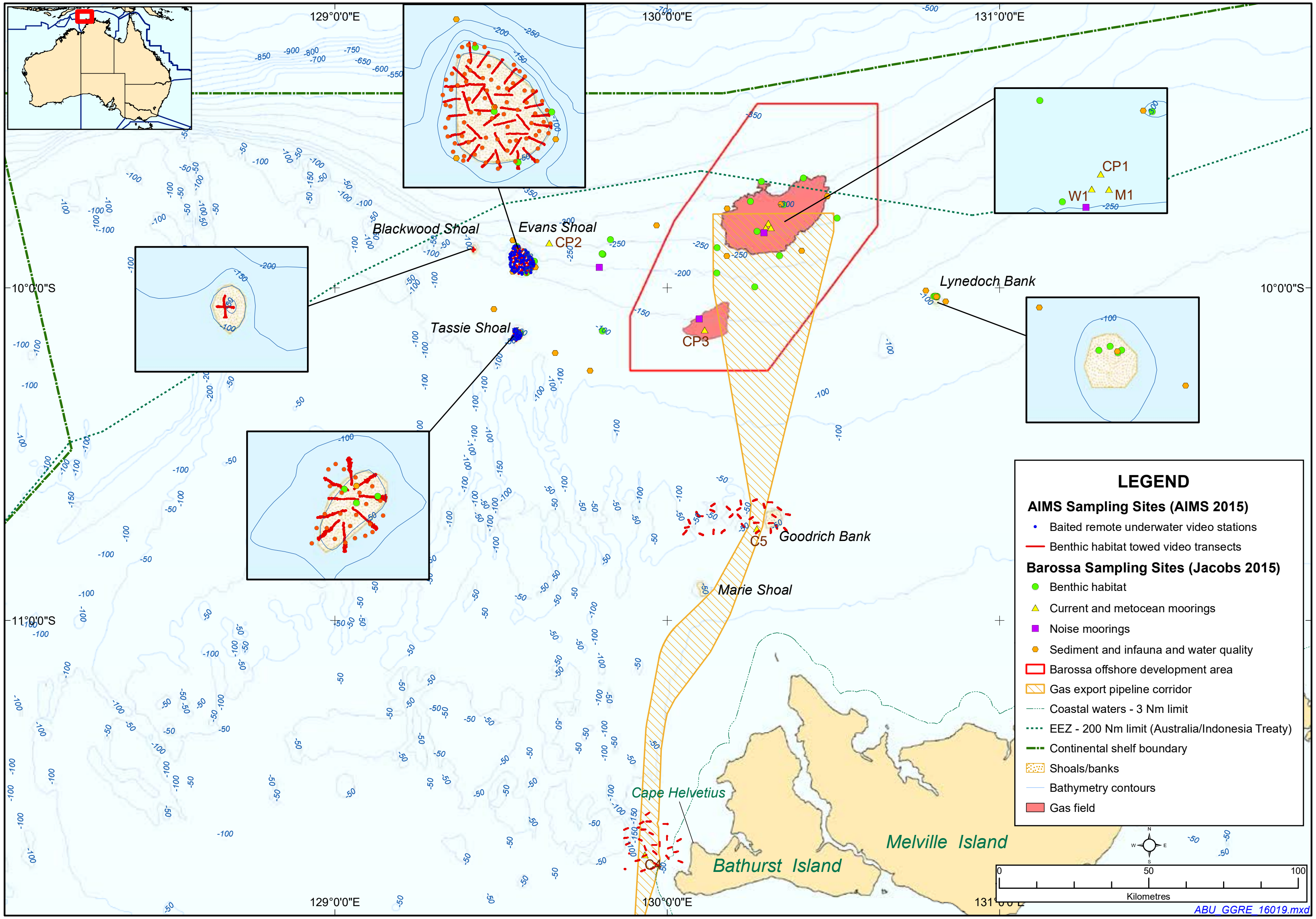


Figure 5-2: Barossa marine studies program sampling sites

5.3 Marine regions and bioregions

The Integrated Marine and Coastal Regionalisation of Australia (IMCRA version 4.0) is a regional ecosystem-based classification of Australia's marine and coastal environment, which has been developed by the Commonwealth Government to assist in regional planning and management of resource development and biodiversity protection (DoEE 2017b). The IMCRA classifies Australia's marine environment into six marine regions, which consist of 41 provincial bioregions.

For the project, the North Marine Region (NMR) is of primary relevance as the Barossa offshore development area and the gas export pipeline corridor are located within this region. However, the area of influence encompasses some of the North-west Marine Region (NWMR). These marine regions are summarised further below.

5.3.1 North Marine Region

The project is located within the NMR, as defined in DoEE's Marine Bioregional Plan for the North Marine Region (former Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2012a)). The NMR covers Commonwealth waters from the western side of Cape York in the east, to the WA–NT border in the west (**Figure 5-3**).

The NMR encompasses a number of regionally important marine communities and habitats, which support a high biodiversity of marine life and feeding and breeding aggregations, including the Gulf of Carpentaria coastal zone and the submerged coral reefs of the Gulf of Carpentaria.

The key physical characteristics of the NMR include:

- a wide continental shelf, with water depths averaging less than 70 m
- the Van Diemen Rise, which provides an important connection between the Joseph Bonaparte Gulf and the Timor Trough. This feature includes a range of geomorphological features, such as shelves, shoals, banks, terraces and valleys.
- a series of shallow calcium carbonate-based canyons (approximately 80 m–100 m deep and 20 km wide) in the northern section of the region
- numerous limestone pinnacles within the Bonaparte Basin that can extend up to tens of kilometres in length and width
- the Arafura Shelf, which is up to 350 km wide and has an average water depth of 50 m–80 m. The shelf is characterised by features such as canyons and terraces.
- reefs around the perimeter of the Gulf of Carpentaria
- the Gulf of Carpentaria coastal zone, which is characterised by comparatively high levels of productivity and biodiversity
- currents driven predominantly by strong winds and tides.

5.3.2 North-west Marine Region

The NWMR, is defined in DoEE's Marine Bioregional Plan for the North-west Marine Region (DSEWPaC 2012b). The NWMR covers Commonwealth waters from the WA-NT border in the north, to Kalbarri in the south (**Figure 5-3**).

The NWMR encompasses a number of regionally important marine communities and habitats, which support a high biodiversity of marine life with feeding and breeding aggregations, including at Ashmore Reef, Cartier Island and Seringapatam Reef. Other important ecological features in the NWMR include:

- the continental slope demersal fish communities that support important marine communities which have a high species diversity and endemism
- the carbonate bank and terrace system of the Sahul Shelf which is a unique seafloor feature contributing to the biodiversity and productivity of the local area
- Rowley Shoals
- Ningaloo Reef.

Refer to **Section 5.7.8** for discussion of the key ecological features (KEFs) as relevant to the project area.

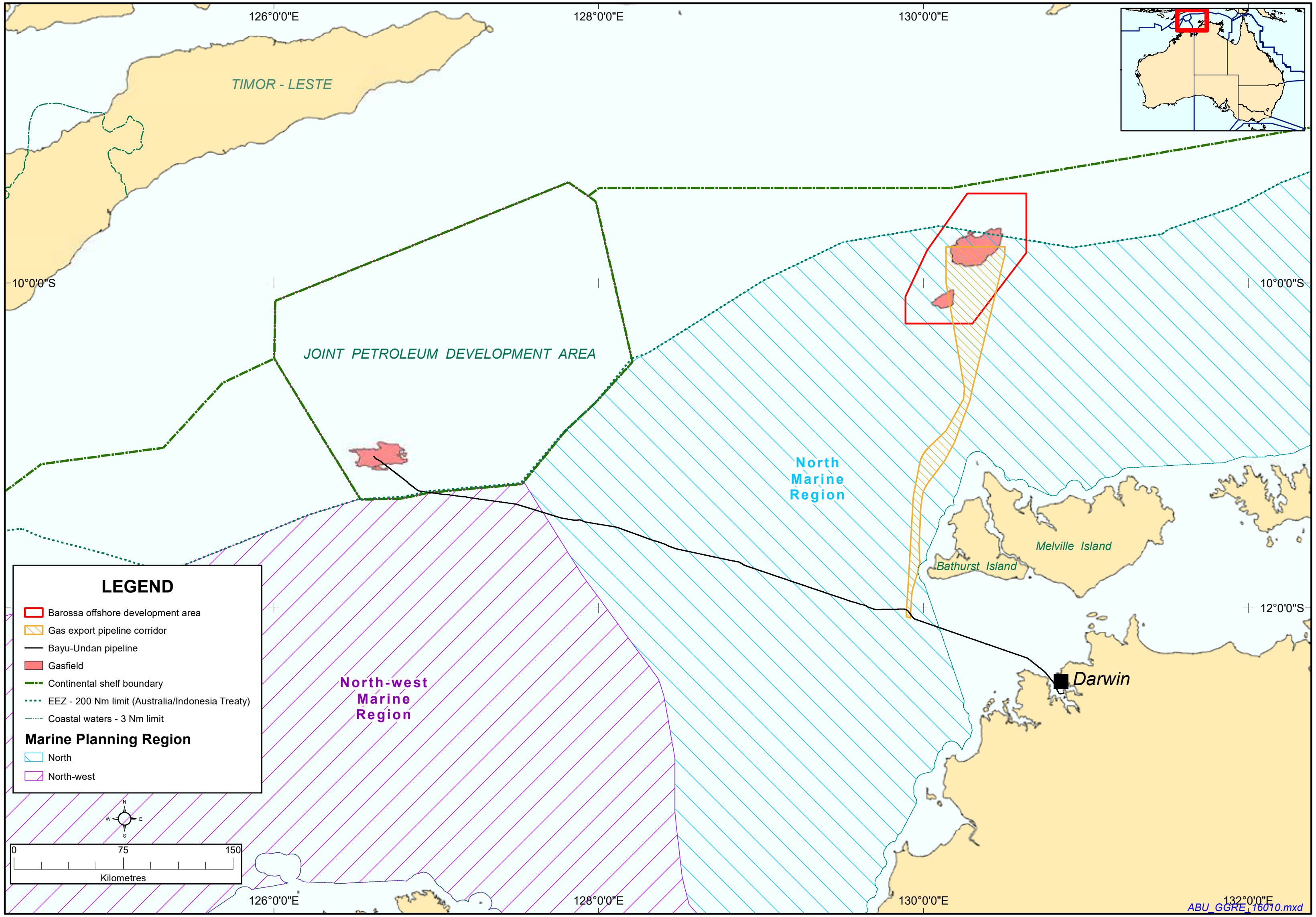


Figure 5-3: Marine regions relevant to the proposal

5.3.3 Timor Transition bioregion

The project is located in the Timor Transition bioregion which is within the broader NMR and covers an area of 24,040 km^2. It predominantly comprises shelf terrace and slope that extends into waters 200m-300m deep in the Arafura Depression. The substrate ranges from sand and soft muddy sediments to hard rocky substrate that contains distinct benthic communities associated with cooler water upwellings (DSEWPaC 2012a). The oceanographic environment is mainly influenced by tides, with some influence from the Indonesian Throughflow (ITF). These open ocean waters support pelagic species, including whale sharks, an unusual array of threadfin fish species and distinct genetic stocks of red snapper (*Lutjanus erythropterus*).

5.3.4 North-west Shelf Transition bioregion

The gas export pipeline corridor traverses both the Timor Transition (**Section 5.3.2**) and the North-west Shelf Transition bioregions. The North-west Shelf Transition covers the mostly shallow waters (< 100 m) between Cape Leveque (WA) and the Tiwi Islands (NT). This transition has a diverse seafloor topography including submerged terraces, carbonate banks, pinnacles, reefs and sand banks.

5.4 Physical environment

This section describes the broader climatic and oceanographic (metocean) conditions, bathymetry and seabed features, water and sediment quality, underwater noise and air quality in relation to the project area. The physical environment has a key influence on the biological environment, as discussed in **Section 5.5**. The information presented is based on the data collected by ConocoPhillips and AIMS for the Barossa marine studies program and supplemented by publicly available data.

5.4.1 Climate

The Bonaparte Basin and Timor Sea region experience a tropical climate and a distinct summer monsoonal "wet" season from October to March followed by a typically cooler winter "dry" season from April to September. During the wet season the south-westerly winds can generate thunderstorm activity, high rainfall and cyclones, while in the dry season the easterly winds result in dry and warm conditions with very little rainfall (Fugro 2015). In addition, the region may also be subject to tropical squalls which are characterised by very high short period wind gusts.

The variation in seasonal air temperatures in the region is small. The mean maximum summer and winter air temperatures recorded at Pirlangimpi Airport on Melville Island (the closest meteorological station to the project) range between 33.6 °C in October/November and 31.2 °C in July (Bureau of Meteorology (BoM) 2017a). The annual maximum temperature is 32.4 °C and the minimum temperature 22.3 °C (BoM 2017a). The average tropical cyclone frequency for the Timor and Arafura Seas region is one cyclone per year with cyclones most commonly occurring between November and April (BoM 2017b).

Meteorological data are based on long-term climate records from the BoM weather station located at Melville Island, which is considered representative of the regional environment of the project area. Refer to **Section 5.4.6** for a summary of the local meteorological conditions recorded during the Barossa marine studies program.

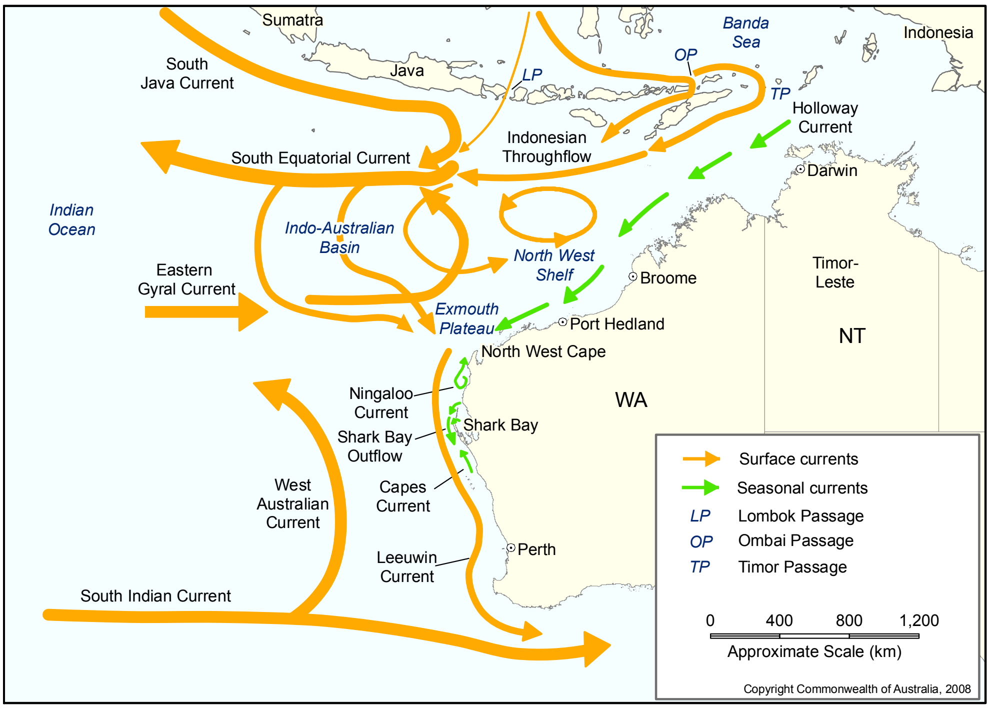
5.4.2 Oceanography

Broad scale oceanography in the northern Australian offshore area is complex, due to the barrier of islands and submerged reefs in the Torres Strait that prevent tidal energy entering the region from the Coral Sea (DSEWPaC 2012a).

The large-scale currents of the Timor and Arafura seas are dominated by the ITF current system (**Figure 5-4**). This current is generally strongest during the south-east monsoon from May to September (Qiu et al. 1999). The ITF brings warm, low salinity, oligotrophic waters through a complex system of currents, linking the Pacific and Indian Ocean via the Indonesian Archipelago (Department of State Development (DSD) 2010). The strength of the ITF fluctuates seasonally, reaching maximum strength during the south-east monsoon, and weakening during the north-west monsoon.

The Holloway Current, a relatively narrow boundary current that flows along the north-west shelf of Australia between 100 m and 200 m depth, also influences the seas in the area (Fugro 2015). The direction of the current changes seasonally with the monsoon, flowing towards the north-east in summer and the south-west in winter (Fugro 2015).

Local tidal and wind influences also play an important role in affecting the broad scale oceanography along the north-west shelf of Australia. For example, the large tides along the north Australian coast can generate large internal waves (amplitudes of up to 100 m) across the region that can then produce unusually high currents (Fugro 2015). Tidal flows are also responsible for driving the long-term transport patterns through the region.



(source: DEWHA 2008c)

Figure 5-4: Key regional currents influencing north-west Australian waters

5.4.2.1 Currents and tides

Water movement in the NMR is influenced primarily by wind and tidal activity and less by ocean currents. Smaller scale surface currents reflect seasonal wind activity, flowing easterly to north-easterly during the wet season and west to south-westerly during the dry season (Heyward et al. 1997). Local wind-driven surface currents can reach speeds of 0.6 metres per second (m/s) during monsoonal wind surges, however, more typical speeds are in the range of 0.2 to 0.3 m/s (Heyward et al. 1997). Average current speeds in the Barossa offshore development area ranged from 0.22 m/s at the near-surface to 0.14 m/s at 210 m below mean sea level (MSL) (Fugro 2015). In situ measurements have shown that current directions can vary with water depth and at specific sites within the Barossa offshore development area demonstrating the complexity of water movement in the area.

Tide activity across the region is complex, resulting in a combination of both diurnal and semi-diurnal tides. However, tidal activity is typically dominated by semi-diurnal tides, with two daily high tides and two daily low tides. The highest astronomical tide recorded at Tassie Shoal (32 km west of the Barossa offshore development area) is 1.4 m above MSL and the lowest astronomical tide is 1.8 m below MSL (Consulting Environmental Engineers (CEE) 2002). The mean tidal range is 2.2 m at spring tides and 0.3 m at neaps (CEE 2002). Measurements of ocean currents at Tassie Shoal show water movement is strongly tidal, with typical speeds in the range of 0.1 to 0.4 m/s and peak speeds up to 0.8 m/s (CEE 2002).

Baseline metocean studies – overview and methods

Over a 12-month period (July 2014 – July 2015), three mooring sites were deployed within the Bonaparte Basin to record temperature and salinity throughout the water column (**Figure 5-2**), two within the Barossa offshore development area (CP1 and CP3) and one near Evans Shoal (CP2). An additional two mooring sites were deployed between March and July 2015; one approximately 100 km south of the Barossa offshore development area (C4) and another approximately 10 km west of Bathurst Island (C5) to record oceanographic conditions in the vicinity of the potential gas export pipeline. The locations of the mooring sites were carefully selected and are considered adequate to inform a detailed understanding of the baseline metocean conditions experienced in the Barossa offshore development area and surrounds, and the hydrodynamic model which underpinned the discharge modelling studies.

The mooring sites consisted of a combination of conductivity, temperature and depth (CTD) sensors (mid to upper water column) (14 at CP1 and CP2) and Aanderaa Seaguards (SG) (one at CP1, CP2, C4 and C5, and two at CP3; lower water column) that measured currents (speed and direction), conductivity, temperature and pressure. From these measurements salinity and depth data were derived. In addition, one Seabird SBE 53 temperature and depth sensor was located at the base of the mooring south-west of the Barossa offshore development area (CP3).

During the same period, these moorings also captured current speed and direction. One TRDI Workhorse Acoustic Doppler Current Profiler was installed on all three moorings, one TRDI Quarter Master Acoustic Doppler Current Profiler was installed on CP1 and CP2 to measure these parameters in the mid to upper water column, and one SG (as mentioned above) to measure data in the lower water column. The Seabird on the mooring located to the south of the Barossa offshore development area (CP3) was used to determine water level.

Another two moorings (in addition to CP1 to C5), W1 and M1, were deployed approximately 1.7 km south-west and south-east respectively of mooring CP1 in the Barossa offshore development area (**Figure 5-2**). Mooring W1 consisted of a Datawell Waverider Buoy configured to measure wave parameters throughout the monitoring period. Mooring M1 consisted of a Met Buoy configured to measure meteorological parameters including wind, air temperature, air pressure and humidity.

The key observations from the baseline metocean studies are incorporated into the following sections.

5.4.2.2 Waves

Waves in the region are composed of locally generated sea waves in response to local wind activity and swell waves created by distant wind activity. Wave height is generally between 0.6 m and 0.8 m, coming from the west in the wet season and from the east in the dry season. Waves at Tassie Shoal typically approach from west to southwest throughout the year (CEE 2002). Cyclones and tropical storms can greatly increase wave heights by up to 8 m in the outer Timor Sea during the cyclone season (Przeslawski et al. 2011).

The wave climate offshore of the north-west shelf of Australia is normally dominated by the passage of storms over the southern Indian Ocean (Fugro 2015). However, between October and March, the wave climate is controlled by the south-westerly monsoon winds. This combination of wind directions may lead to concurrent swells approaching from different directions. The sea wave climate also reflects the seasonal wind regime, with waves predominantly from the south-west in summer and from the east in winter.

Soliton (i.e. solitary wave) activity (both solitons of elevation and depression) was observed during the field surveys in both the Barossa offshore development area (CP1) and in the vicinity of Evans Shoal (CP2). Soliton activity occurs as a result of large internal waves propagating along an oceanic density interface, such as the thermocline. In general, the soliton events recorded were characterised by a sharp increase in current speed, a rapid change in current direction and fluctuation in seawater temperature (Fugro 2015). While many of the solitons were individual events, most were part of a soliton packet, i.e. two or more events travelling at similar speeds and depth. Most activity occurred between April and July and, while recorded from all current directions, the main direction associated with soliton events was towards the south-east and east (Fugro 2015). The effects of the events were observed to influence current from around 70 m down to approximately 200 m below mean sea level (MSL).

5.4.2.3 Temperature

Surface water temperatures in the Barossa offshore development area generally ranged between 27 °C and 30 °C while temperatures above the seabed ranged between 11 °C and 13 °C (Jacobs 2016a). Sea temperatures in the upper water column of the Barossa offshore development area (represented by instrument recordings at approximately 34 m below MSL at CP1) were recorded as reaching a maximum of 30.9 °C in summer and a minimum of 24.7 °C in spring (Fugro 2015). The minimum sea temperature of 10.6 °C was recorded near the seabed at 253 m below MSL in spring. Mean temperatures ranged from 28.1 °C at 34 m below MSL (summer) to 12.6 °C at 253 m below MSL (summer).

Other studies have shown that mean monthly temperatures in the central Timor Sea are typically between 26 °C and 30 °C, decreasing to approximately 12 °C at 300 m, with waters expected to be stratified all year round, but with the thermocline nearer the surface (50 m depth) in summer, compared to winter (100 m depth) (Woodside 1999).

Waters are characterised by thermal stratification that varies in strength according to the season (IMCRA Technical Group 2006). Thermoclines were encountered at all sites, indicating the potential presence of separate subsurface current streams. During marine water quality studies, the thermocline (considered to lie in the zone in which the greatest temperature decrease occurs) was closest to the surface during the wet season (between 40 m and 70 m) and deeper in the water column during the dry and transitional seasons (between 70 m and 150 m and between 100 m and 150 m respectively) (Jacobs 2016a). This is understood to be due to strong, continual winds during the dry and transitional seasons causing the depth of the mixed layer to be greater (Jacobs 2016a). Extreme weather events, such as cyclones, also promote mixing of water layers.

5.4.3 Bathymetry and seabed features

5.4.3.1 Barossa offshore development area

The water depths in the Barossa offshore development area are between approximately 130 m and 350 m, with the southern portion being shallower. Based on the available information, including the bathymetry and seabed topography data derived from previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across the area (refer **Section 5.2**), the seabed within the area is generally flat and located on a plain feature that is devoid of any significant bathymetric features. **Figure 5-5** shows the spatial extents of the data collected. The geophysical surveys undertaken also reported that the seabed was smooth and featureless with the sediments interpreted to comprise predominantly fine clayey sand (Fugro 2016). The only relic seabed features observed were slight undulating sand waves (< 25 cm in height) and widespread bioturbation (i.e. burrows, mounds and tracks) (Jacobs 2016c, **Appendix C**). The marine sediments are predominantly silty sand and generally lack hard substrate. An example of the typical seabed terrain observed across the Barossa offshore development area is provided in **Figure 5-6**.

In general, the benthic habitats observed in the Barossa offshore development area were typical of those expected in offshore environments and were consistent with studies conducted both in areas with similar features and in areas of a similar geographic location (Jacobs 2016c). ConocoPhillips is not aware of any information indicating that the Barossa offshore development area contains any critical or sensitive habitat, nor any benthic habitats that are not represented across other areas and/or regions.

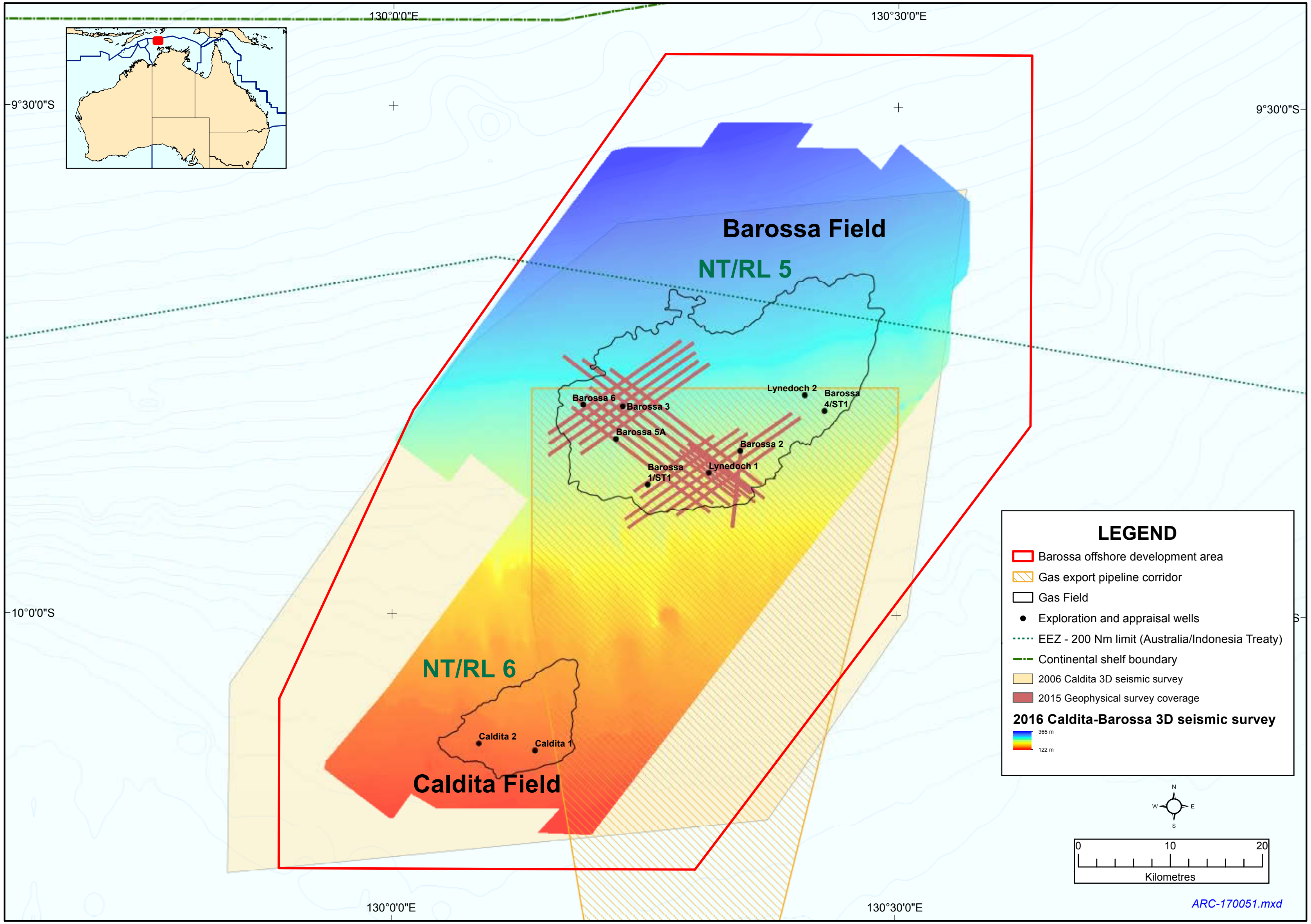


Figure 5-5: Spatial extents of seabed data collected and derived for the Barossa offshore development area

Figure 5-6: Typical seabed terrain in the Barossa offshore development area

5.4.3.2 Gas export pipeline

While the gas export pipeline route within the corridor presented in this OPP is still subject to refinement, a preliminary geophysical survey was completed by Fugro in November 2015 to characterise the seabed along a notional pipeline route within the corridor. The survey methods included multibeam echo sounding, side scan sonar and sub-bottom profiling to provide information on seabed topography. The survey observed that the seabed varied from relatively smooth and gently sloping to irregular areas including seabed channels and ridges with steep gradients (Fugro 2016). Water depth ranged from approximately 240 m in the Barossa offshore development area, to approximately 50 m towards the southern end of the pipeline and approximately 5 m within the shallow water area of the pipeline corridor (**Figure 4-12**)(Fugro 2016).

The seabed in the northern offshore section of the gas export pipeline was characterised by relatively smooth to moderate slopes comprising fine to medium sands/silt and clay, with pockmarks and the occasional outcrop of cemented sediments (Fugro 2016). These seabed features broadly align with those recorded during seabed surveys along the Ichthys pipeline route, which traverses the offshore waters of the NWMR and NMR. The Ichthys pipeline surveys recorded featureless, unconsolidated clay-silt sands along the majority of the route and noted that the most commonly observed features were pockmarks and sand waves, with rock outcrops rare (INPEX 2010).

The southern end of the pipeline, to the west of the Tiwi Islands (including the shallow water area of the pipeline corridor), was characterised by a combination of highly irregular relief and smooth sandy/silty seabed with the occasional outcrops of cemented sediments (Fugro 2016). The areas of irregular relief consisted of predominantly cemented sediments, rock and reef outcrops with patchy areas of soft, loose sediments (Fugro 2016). The areas of mobile sediments were characterised by fine, soft sand which formed megaripples and sandwaves while coarse sediments, comprising sand, gravel and shells, were associated with the rock/reef outcrops (Fugro 2016). Coarser sediments were also located in closer proximity to the offshore shoals/banks (e.g. Goodrich Bank and Marie Shoal), as consistent with that observed from the Barossa marine studies program. An area to the west and north of the Tiwi Islands is a key consideration in terms of technical constraints associated with installation of the pipeline in shallow seabed topography, and will inform the practicability of the final gas export pipeline route.

Future detailed surveys along the gas export pipeline will provide more detailed spatial information about environmental features, such as benthic habitat communities, and engineering constraints (e.g. irregular relief and steep seabed gradient), all of which will inform optimisation of the pipeline route.

5.4.4 Water quality

This section describes the water quality as recorded across the Barossa offshore development area and surrounding features of regional interest (i.e. shoals and banks) during three seasonal field surveys between June 2014 and March 2015 (Jacobs 2016a; **Appendix B**). Water samples, water column profiles, phytoplankton and zooplankton samples were collected on three separate occasions (once each during the wet, dry and transitional seasons) from 17 sites in order to represent the seasonal variability for the region. Water quality sampling sites for the field surveys were located in the Barossa offshore development area (six sites), and in the vicinity of Evans Shoal (four sites), Tassie Shoal (four sites) and Lynedoch Bank (three sites) (**Figure 5-2**). Water samples were collected from three depths at each of the sites; near-surface (2 m–5 m), mid-water (half the bottom depth) and one near the bottom (within 5 m of the seabed).

Where appropriate, water quality data have been compared to the Australian and New Zealand Environment and Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ) (2000) guidelines. However, it is important to note that the guidelines are for shallow water areas and not deeper offshore habitats which are exposed to high pressure, low temperature and low oxygenation relative to shallow waters. The chemistry and ecotoxicity of minerals and nutrients are significantly different under these conditions and hence ecological interpretation must account for that. There are currently no water quality or sediment quality guidelines for offshore environments in Australia. The ANZECC & ARMCANZ guidelines are currently the subject of a review, however, the revised guidelines are yet to be published.

Temperature, pH, salinity and dissolved oxygen remained relatively consistent throughout the seasons. Surface water temperatures ranged from approximately 27°C (winter) to approximately 30°C (summer and autumn) with the temperature gradually decreasing with depth to approximately 11°C–13°C above the seabed (Jacobs 2016a). The pH in the surface waters ranged from 8.1 to 8.3 pH units while the pH at the seabed ranged from 7.7 to 7.9 pH units (Jacobs 2016a). The decrease in pH is due to oxidation of organic matter (Jacobs 2016a). When dead organisms fall from the surface layers and start decaying they liberate CO_2, which dissolves into the water producing carbonic acid that undergoes almost instantaneous ionisation into hydrogen ions and thus decreases pH (Hinga 2002).

There was little difference in salinity between the surface water and the bottom water at all sites during all seasons. Salinity at the surface waters was approximately 34 ppt, which was approximately 0.7 ppt lower than the bottom water of the deepest sites (Jacobs 2016a). As these water quality sampling sites were remote from any large land masses, the only potential factors affecting surface water salinity were climatic ones (i.e. precipitation or evaporation).

Dissolved oxygen was high in the surface water (90–100% saturation at all sites for each season) decreasing to approximately 35% saturation in the bottom water of the deepest sites (Jacobs 2016a). The dissolved oxygen of the shallowest sites stayed constant from surface to bottom waters. Dissolved oxygen was highest near the surface waters, where light for photosynthesis is strongest and oxygen exchange between the atmosphere and the ocean is at a maximum (Jacobs 2016a). Waves, wind and currents act to mix dissolved oxygen through the upper section of the water column. These processes become progressively weaker as depth increases. Below the upper mixed layer, the oxygen content decreased with an increase in depth due to oxidation of organic matter resulting in the consumption of oxygen.

The main seasonal variation observed was the depth of the thermocline (see **Section 5.4.2.3**), which was relatively small in comparison to oceans further away from the equatorial line, which experience greater seasonal variation. The shift in the thermocline is directly linked to the change in profiles of both the dissolved oxygen, salinity and warming of the mid water layers during summer. Surface water temperatures, trade winds and the Coriolis effect have a distinct correlation to the movement of such mid-water temperature changes; the data collected over the seasonal changes successfully demonstrates the natural processes in place and their effect on deep water mixing for the latitude of the specific area.

Turbidity was very low throughout the water column and displayed minimal seasonal variability (< 0.2 nephelometric turbidity units (NTU)) (Jacobs 2016a). Approximately 20 m–50 m above the seabed, the turbidity was slightly elevated and increased with depth, possibly caused by the action of currents passing over the seabed causing some turbulence and re-suspension of sediments (Jacobs 2016a).

Chlorophyll a concentrations were low throughout the water column at all sites and during each season, less than the ANZECC & ARMCANZ (2000) trigger value of 0.9 µg/L. Chlorophyll a concentrations peaked at shallower depths during winter (30 m–50 m) and deeper depths during summer and autumn (50 m–70 m) (Jacobs 2016a). During summer, the zone of maximum productivity lies some distance below the surface, most likely due to optimising the requirement for light and nutrients (Jacobs 2016a).

Nutrient concentrations increase with depth and light penetration is greater in summer, therefore, the depth of maximum productivity would be greater in summer than winter.

Whilst the majority of metal concentrations were below the ANZECC & ARMCANZ (2000) guidelines, copper concentrations were occasionally (four sites sampled in winter and five sampled in summer) slightly above the ANZECC & ARMCANZ guideline for 99% species protection of 0.3 µg/L. There were also slight increases in arsenic, barium chromium and nickel in the bottom waters of the deepest sites within the Barossa offshore development area and Evans Shoal, however, all were below ANZECC & ARMCANZ guidelines. The distribution of some metals in seawater have been reported to be significantly influenced by the uptake of phytoplankton in the surface waters, subsequent decomposition of the organic matter produced and remineralisation in deep waters (Abe 2004).

Total recoverable hydrocarbons and benzene, toluene, xylenes and naphthalene (BTEXN) were below the laboratory reporting limits at all sites and depths for each season (Jacobs 2016a). There was little difference in the hydrocarbon profiles between sites, indicating a lack of hydrocarbons in the areas sampled (Jacobs 2016a).

The naturally occurring radioactive materials (NORMs) radium^{226} and radium^{228} were above the minimum reporting limit at a number of sites during the three surveys, while thorium^{228} was not detected at any site (Jacobs 2016a). There are no ANZECC & ARMCANZ (2000) trigger values associated with NORMs, however, there are guideline values for drinking water National Health and Medical Research Council (NHMRC) & ARMCANZ (2011). According to these guidelines, concentrations of radium^{226} and radium^{228} should not be above 4.89 becquerel per litre (Bq/L) and 1.98 Bq/L respectively. All concentrations at all sites sampled during the three surveys were low (< 0.49 Bq/L) and below the threshold concentrations cited above.

Overall, there was very little change in the majority of water quality parameters recorded between the surveys, indicating that minimal seasonal variation is experienced in the Barossa offshore development area. The water quality throughout the water column was consistent with expected trends given the location and natural processes like wind, waves and current movements that are found in deeper water offshore marine environments.

Assessment of existing hydrocarbon seeps

Airborne laser fluorosensor studies (Martin and Cawley 1991; Cowley 2001) and satellite-based synthetic aperture radar (SAR) studies (Logan et al. 2006) have been carried out in the Arafura Sea, including coverage of the Barossa offshore development area, to detect possible hydrocarbon seepage. The data from these studies shows no evidence of hydrocarbon seepage when compared with areas of confirmed hydrocarbon seepage globally. An integrated study conducted at a site of surface slicks interpreted from the SAR data, involving side-scan sonar and echo-sounder techniques, found no evidence of active hydrocarbon flares related to seepage (Rollet et al. 2009). Additional analysis of the sediments in the area did find elevated levels of CH_4 and CO_2, however, these were confirmed to originate from the decay of organic matter rather than from hydrocarbon seepage (Grosjean et al. 2007; Logan et al. 2006).

A review of Australian offshore hydrocarbon seepage studies (Logan et al. 2010) concluded that the majority of Australia's offshore basins are unlikely to be characterised by active hydrocarbon seepage given the relatively (on a global scale) low level of sediment deposition that is considered insufficient to drive active seepage (Logan et al. 2010). The only sites of proven natural hydrocarbon seepages in offshore Australian waters occurred on the Yampi Shelf (located approximately 450 km south-west of the Barossa offshore development area). Occurrences of waxy bitumens have been recorded in waters off the NT, however, these tend to be highly weathered, and while they provide direct evidence of natural hydrocarbon seepage, they have been confirmed as originating from Indonesian waters (Logan et al. 2010).

5.4.5 Sediment quality

The characteristics of the marine sediments in the Barossa offshore development area and surrounding features of regional interest (i.e. shoals and banks) were determined from 14 sites; six sites in the Barossa offshore development area, three sites at Evans Shoal, three sites at Tassie Shoal and two sites at Lynedoch Bank (**Figure 5-2**; **Appendix C**). These sites were in the same location, or in close proximity to, the water quality sampling sites. Sediment samples were not collected at three of the water quality sampling sites (SP7, SP11 and SP16) due to the occurrence of benthic primary producer habitat (BPPH) (see **Section 5.5.2**). The sites surveyed ranged in depth from around 70 m on the top of shoals/banks to approximately 280 m in the Barossa offshore development area.

The sediment types observed during the survey were comparable with those found in local and broader regional seabed habitat mapping studies undertaken in the Eastern Joseph Bonaparte Gulf and Timor Sea (URS 2005, 2008; Fugro 2006a, b; Anderson et al. 2011; Przeslawski et al. 2011).

Sediments sampled showed a gradual transition in composition over large spatial scales, particularly between the Barossa offshore development area and the shallow shoals (Jacobs 2016b). This trend is related to depth (and, therefore, current speeds) and prevailing current or weather direction. In general, sediments transitioned from the finer deep sediments in the Barossa offshore development area to the coarse shallow water sediments (gravelly sands) around the shoals/banks (Jacobs 2016b). Within the Barossa offshore development area there was a slight east–west transition in sediment type, with finer sediments (sandy muds) in the east to coarser muddy sands in the west (Jacobs 2016b). This is likely due to the prevailing current direction, which flows along a south-eastward to north-westward axis near the seabed (Fugro 2015).

Whilst the majority of metal concentrations were below the ANZECC & ARMCANZ (2000) guidelines, cobalt (11 sites) and nickel (two sites) were recorded at concentrations above the trigger values (Jacobs 2016b). Nickel is commonly recorded at high levels in Australian sediments (Commonwealth of Australia 2009). Total recoverable hydrocarbons and BTEXN were below the laboratory reporting limits at all sites (Jacobs 2016b).

NORMs were not detected at any site, with the exception of radium^{226} at two sites (Jacobs 2016b). While radium^{226} was recorded above the minimum reporting limit at these sites the levels were well below the ANZECC & ARMCANZ (2000) trigger value.

Nitrogen, phosphorus and organic carbon are released when organic compounds decay. The highest concentrations of nitrogen and organic carbon were associated with deepest and the finest sediment in the Barossa offshore development area (Jacobs 2016b). Deep-water sediment habitats are predominantly depositional, as indicated by their relatively high particle size distribution fines component and nutrient content. The benthic communities of these habitats are consumers rather than primary producers and, therefore, utilise the increased nutrient component of sediments (Jacobs 2016b).

5.4.6 Air quality and meteorology

The project is offshore and remote from residential and permanent urban populations or sensitivities. Therefore, local air quality is not expected to be significantly influenced by anthropogenic sources. Only localised and temporary reductions in air quality associated with offshore shipping and oil and gas exploration and development activities are expected in the vicinity of the project.

Summary statistics of local meteorological conditions recorded by the Met Buoy (Mooring M1) located within the Barossa offshore development area are provided in **Table 5-2** (Fugro 2015).

Table 5-2: Summary of local meteorological conditions

Parameter	Maximum	Minimum	Average
Wind speed (metres per second (m/s))	17.8	0.0	6.4
Wind gust (m/s)	21.0	0.2	7.3
Air temperature (°C)	34.0	22.8	27.7
Atmospheric pressure (millibars)	1,017.9	1,002.2	1,010.8
Relative humidity (%)	96.2	45.0	75.5

5.4.7 Underwater noise

JASCO conducted a long-term baseline acoustic environment study program in the Barossa offshore development area over the period July 2014 to July 2015 (JASCO 2016a; **Appendix E**).

Data were acquired with three Autonomous Multichannel Acoustic Recorders (AMARs) deployed close to the seabed for extended periods at three stations. The acquired acoustic data were analysed to quantify the ambient sound levels, the presence of anthropogenic (human-generated) activity, and the acoustic presence of marine mammals and fish. The locations of the AMAR logger sites (J1, J2 and J3), relative to the metocean moorings (CP1, CP2 and CP3), are shown in **Figure 5-2**.

Key conclusions from the results of the baseline noise study are:

- the soundscape is dominated by naturally occurring sources (i.e. wind and waves), with some contributions from biological sources (primarily fish and Omura's whales)
- the average ambient sound levels for this region were recorded as ranging between approximately 97 re 1 micropascal (µPa) and 119 decibels (dB) re 1 µPa (recommended sound pressure level (SPL)), with low anthropogenic sound presence noted
- there were minor daily variations in ambient sound levels (due to fish chorusing events), with weather events being the main influence
- there was generally a low level of anthropogenic activity, with the exception of the period where the Barossa appraisal drilling rig and associated support vessels were in the area (departed April 2015). While these sources were a dominant feature of the soundscape at close range, they were considered less influential than the natural and biological sources typical of the region. Therefore, the impact can be considered localised
- vessel movements were a minor contributor to the soundscape with the mean daily vessel detections ranging from 0.1–2.8 vessels.

In terms of biological presence, it was determined that:

- Omura's whale (dwarf fin whale) were frequently present in the area between April and September inclusive, with a peak in June and July
- Pygmy blue whales were detected in August 2014 and between late May and early July 2015, during their northward migration. No detections were made from the southward migration, suggesting a different migration path may be used.
- Bryde's whales were present in the region from January to early October
- Humpback whales were absent from the area. This data aligns with currently recognised migration patterns for this species (**Section 5.6.2**)
- Unknown beaked whale species were detected on four days over the monitoring period
- A number of odontocete species (toothed whales) were detected, with many species detected on a daily basis. Identification of specific species is difficult and requires detailed manual analysis. However, analysis of the data collected has indicated the presence of short-finned pilot whales. Other odontocete species that may be present in the area including false killer whales, pygmy killer whales, melon-headed whales, Risso's dolphins, Fraser's dolphins, spotted dolphins, rough-toothed dolphins, and spinner dolphins as they have previously been observed in the broad area.
- Fish chorusing at dawn and dusk was present throughout the year at all stations. The intensity of the chorusing activity varied with season but the timing was relatively consistent. Fish chorusing is not currently able to be analysed through automated detections and there is a general lack of knowledge around vocalisations of the most common fish species present in the Timor Sea. However, it is considered possible that a large number of the chorusing calls are from members of the Lutjanidae (snapper) family.

The results of this baseline noise study are considered in the context of the known migration and aggregation patterns of marine fauna in the regional area (refer **Section 5.6**), and have also helped inform the assessment of potential noise effects taking into account ambient conditions (**Section 6.4.5**).

5.5 Biological environment

5.5.1 Overview and Matters of National Environmental Significance

This section describes the existing biological values and sensitivities in relation to the project and surrounding marine environment. Three separate searches of the online EPBC Act Protected Matters database were undertaken: the Barossa offshore development area, gas export pipeline corridor and area of influence.

The EPBC database searches of the Barossa offshore development area and gas export pipeline corridor are considered appropriate to represent those listed marine species that may occur, or have habitat, in the immediate project area (**Figure 4-2** and **Figure 4-3**). A search based on the area of influence was undertaken to identify those species potentially affected in the unlikely event of a large-scale spill.

The results of the Protected Matters search are summarised in **Table 5-3** and included in **Appendix P**. The summary in **Table 5-3** represents a consolidation of the search outcomes for all three of the above search areas.

Table 5-3: Summary of MNES identified as relevant to the project

MNES	Number	Status
World Heritage properties	None	Not applicable
National Heritage places	None	Not applicable
Wetlands of International Importance	Project area: None Area of influence: Ashmore Reef National Nature Reserve	While significantly distant from the Barossa offshore development area (750 km south-west), the Ashmore Reef National Nature Reserve is within the area of influence
Listed Threatened Ecological Communities	None	Not applicable
Listed threatened species (**Section 5.6**)	Project area: **20** (Mammals – 4, Reptiles – 6, Fish – 1, Sharks – 6, Birds – 3) Area of influence: **29** (Mammals – 4, Reptiles – 8, Fish – 1, Sharks – 6, Birds – 10)	Project area: Critically endangered – 3, Endangered – 6, Vulnerable – 11 Area of influence: Critically endangered – 7, Endangered – 8, Vulnerable – 14
Listed migratory species (**Section 5.6**)	Project area: **41** (Migratory marine species – 28, Migratory marine birds – 5, Migratory wetland species – 8) Area of influence: **71** (Migratory marine species – 29, Migratory marine birds – 15, Migratory wetland species – 21, Migratory terrestrial species – 6)	Project area: Critically endangered – 2, Endangered – 5, Vulnerable – 11 Area of influence: Critically endangered – 3, Endangered – 6, Vulnerable – 12
Commonwealth marine areas (**Section 5.7.5** and **Section 5.7.6**)	Exclusive Economic Zone and Territorial Sea Extended Continental Shelf Project area: AMPs – Oceanic Shoals Area of influence: AMPs – Oceanic Shoals, Arafura, Arnhem, Kimberley, Ashmore Reef and Cartier Island	AMPs: Oceanic Shoals, Arafura, Arnhem, Kimberley, Ashmore Reef and Cartier Island
Great Barrier Reef Marine Park	None	Not applicable
Nuclear actions (including uranium mines)	None	Not applicable
Protection of water resources from coal seam gas development or large coal mining development	Not applicable	Not applicable

5.5.2 Benthic habitats and communities

Benthic habitats predominantly refer to communities consisting of marine plants, such as seagrass and macroalgae, or invertebrates such as reef-building corals.

Previous surveys in the Timor Sea indicate that between 50 m and 200 m depth, the benthos consists of predominantly soft, easily re-suspended sediments (Heyward et al. 1997; URS 2005, 2007). The diversity and coverage of epibenthos is low and organisms present are predominantly sponges, gorgonians and soft corals (Heyward et al. 1997; URS 2005, 2007).

The characteristics of the benthic habitats in the Barossa offshore development area and surrounding shoals and banks were determined from 25 ROV sampling sites: 14 sites in the Barossa offshore development area and surrounds (includes seamounts 9 km–18 km to the west and scarps within the Barossa offshore development area), four sites at Evans Shoal, three sites at Tassie Shoal and four sites at Lynedoch Bank (**Figure 5-2**). The sites surveyed ranged in depth from approximately 300 m in the Barossa offshore development area, where light attenuation, temperature and water energy was low, to approximately 10 m–30 m on the top of shoals/banks. The depths surveyed at > 100 m are considered to be beyond the photic zone and, therefore, the benthic environments in these areas are unable to support photosynthetic organisms, such as photosynthetic algae and light-dependent coral communities. Infauna (i.e. burrowing fauna which live in the marine sediments) were sampled at 14 sites in conjunction with the sampling of the marine sediments (**Section 5.4.5**).

The nearest seabed features of regional interest to the Barossa offshore development area (Evans Shoal, Tassie Shoal and Lynedoch Bank) and the gas export pipeline corridor (Goodrich Bank, Marie Shoal and Shepparton Shoal) are discussed in **Section 5.5.3**.

5.5.2.1 Barossa offshore development area

The Barossa offshore development area is situated on a plain comprising homogenous flat, soft sediments (Przeslawski et al. 2011). Studies in the field have observed the seabed to comprise mostly of silty sand lacking in any hard substrate, with relic seabed features (such as sand waves) widespread (Jacobs 2016c). Benthic macrofauna groups observed in the video footage included octocorals (particularly sea pens) and motile decapod crustaceans (mostly prawns and squat lobsters), which were recorded in relatively low numbers. Other biota observed included anemones, starfish, brittle star and soft corals.

The frequent bioturbations (burrows, mounds and tracks) observed suggest a number of burrow-living decapods (such as prawns) may be present (Jacobs 2016c). These species are more active at dawn, dusk or at night in habitats lacking cover and hence, less likely to be recorded during daylight surveys (Jacobs 2016c).

Infaunal communities in the Barossa offshore development area were characterised by burrowing taxa and demersal fish, namely foraminifera (an amoeboid protist), nematodes, *Bregmaceros sp*. (codlets), tube-forming Onuphid polychaetes and the superb nut shell *Ennucula superba*. The communities were characterised by low abundance (five to 15 individuals) and species diversity (five to nine taxa). The most commonly represented phyla within the infaunal communities were Annelida (total of eight individuals across the sampling sites), Mollusca and Foraminifera (total of seven individuals) and Crustacea (total of six individuals). Due to the lack of hard substrate, the associated epibenthos was expected to be sparse.

The deep-water benthic characteristics of the Barossa offshore development area are broadly consistent with the results of similar surveys in offshore areas. Surveys for the Sunrise Gas Project, approximately 210 km west, found that epifauna were sparse and were predominantly comprised of hydroids, sponges and crinoids (SKM 2001). Benthic habitat in the GDF Suez (now Engie) Bonaparte Basin retention lease areas (approximately 310 km south-west of the Barossa offshore development area) was recorded as soft sediments with epifauna and sessile benthos generally being sparse and characterised by a limited number of common and widespread taxa (GDF Suez 2011). Infaunal communities were also observed to be typical of soft sediment habitat and dominated by polychaete worms (GDF Suez 2011).

As discussed in **Section 3.6**, a subset of the Perth Treaty area is present within the northern section of the Barossa offshore development area. Drawing on the results of the Barossa marine baseline program, seabed characteristics and benthic habitats of the Perth Treaty area are expected to be consistent with that described above for the Barossa offshore development area. One site within the Perth Treaty area and one site within close proximity were surveyed during the Barossa marine studies program. The sampling sites were located at 303 m and 309 m water depths with predominantly silty sand substrate, slightly undulating seabed (<25 cm in height) and widespread bioturbation (Jacobs 2016c). Observed biota across the two sites included anemones, brittle stars, sea pens, decapod crustaceans and three species of fish.

Representative images of the benthic habitats and macrofauna across the Barossa offshore development area are shown in **Figure 5-7** and the following sub-section (**Section 5.5.2.2**) provides spatial maps of the habitat types across the full Oceanic Shoals marine park and the project area, inclusive of the Barossa offshore development area and the gas export pipeline corridor, derived by AIMS spatial habitat modelling.

a) Silty sandy substrate with a burrowing anemone and widespread bioturbation (southern area)

b) Silty sandy substrate with a teleost fish and widespread bioturbation (southern area)

c) Silty sandy substrate with a sea pen (middle area)

d) Silty sandy substrate with gravelly silty sand substrate, a squat lobster and soft coral (middle area)

e) Silty sandy substrate with a teleost (gurnard) (northern area)

f) Silty sandy substrate with a prawn (northern area)

Figure 5-7: Representative images of benthic habitats and macrofauna across the Barossa offshore development area

5.5.2.2 Gas export pipeline corridor

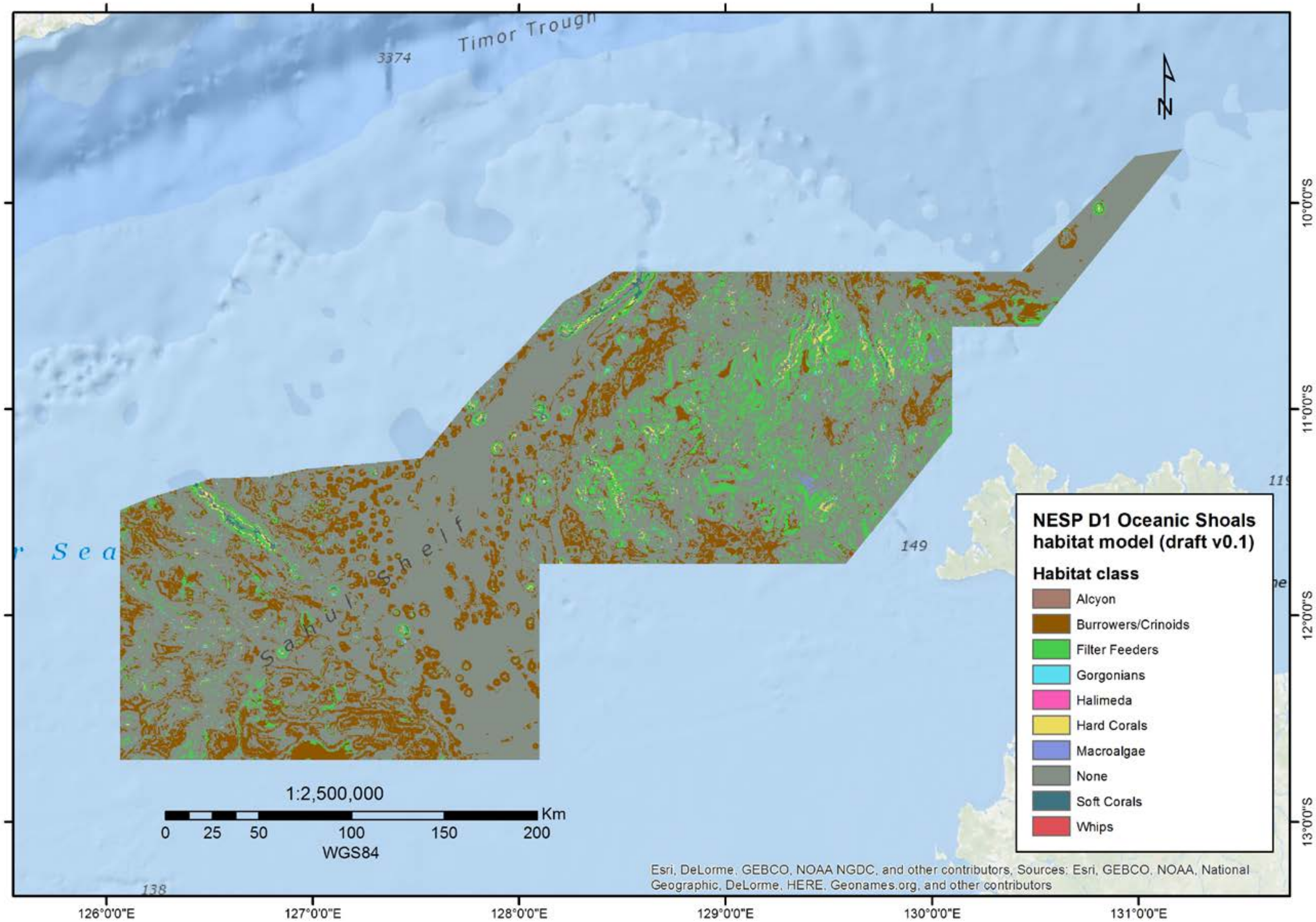
A spatial predictive benthic habitat model of the Oceanic Shoals marine park has been developed by AIMS as part of the Australian National Environmental Science Programme to determine the spatial heterogeneity of the benthic environment and key classes of organisms within the reserve. To ensure the model was robust, ecologically meaningful and sufficiently accurate, it was verified through the use of field data and statistical relationships (between the predictors and field data presence/absence of benthic classes) using a non-parametric statistical method of classification trees (Radford and Puotinen 2016). The model was also subject to testing of random data points to assess accuracy. Using this method, 10 benthic habitat classes across the entire Oceanic Shoals marine park were modelled (Radford and Puotinen 2016). The benthic habitat model is shown in **Figure 5-8**, with an interactive version available at http://northwestatlas.org/ node/1710. The benthic habitats within the area of the Oceanic Shoals marine park that is intersected by the gas export pipeline corridor comprise predominantly of burrowers/crinoids, filter feeders and abiotic areas that support no benthic habitat with some small areas of corals and macroalgae.

A targeted study was undertaken by Przeslawski et al. (2014) on sponge biodiversity and ecology of the Van Diemen Rise and eastern Joseph Bonaparte Gulf and involved sampling of five geomorphic features characteristic of these areas (e.g. bank, terrace, ridge, plain and valley). This study is of broad relevance as the gas export pipeline corridor traverses the Van Diemen Rise. The information from this study was also used to inform the spatial predictive benthic habitat model of the Oceanic Shoals marine park, as discussed above. The study noted that sponge diversity (species richness and biomass) was generally higher further offshore and on raised geomorphic features, particularly banks, when compared to surrounding valley and plain features (Przeslawski et al. 2014). The average sponge species richness recorded on the banks surveyed was 15 species, with terraces and ridges supporting an average of approximately 14 species and approximately nine species respectively (Przeslawski et al. 2014). The valley and plain seabed features had an average species richness of approximately five and one species respectively (Przeslawski et al. 2014). While previous studies have observed a correlation between sponge diversity/community structure and environmental factors such as substrate, depth or slope (or a combination of these), the findings of the targeted study did not observe such a relationship. Przeslawski et al. (2014) suggested that other environmental or biological factors (e.g. ocean currents, light availability and recruitment ability) may be more influential in the area surveyed. It was also stated that spatial and temporal variability may be a contributing factor.

The benthic habitat model of the Oceanic Shoals marine park was extended by AIMS to encompass the entire gas export pipeline corridor and the Barossa offshore development area (**Figure 5-9**). The model of these additional areas was developed using the same methods described above and was possible as benthic habitat data were available within the region outside of the AMP. The model was informed by comprehensive habitat assessments at 18 field sites spanning 800 km of the oceanic shoals of the Sahul Shelf and included additional benthic habitat data held by AIMS and data collected as part of the Barossa marine studies program (Heyward et al. 2017). The accuracy of the model was assessed and showed a good level of accuracy. The majority of the benthic habitats were accurately classified (approximately 80%), with the exception of the 'None' benthic category. The 'None' category had a lower accuracy (approximately 50%) as the model under predicted filter feeder and Halimeda communities, which by their nature can be discrete, stochastic and challenging to model (Heyward et al. 2017).

The seabed habitats and associated biota of two bathymetrically complex areas on the mid-continental shelf that may be within, or in close proximity to, the potential gas export pipeline corridor were characterised in a detailed field survey undertaken by AIMS. The areas of interest are located adjacent to the western side of Goodrich Bank, which is characterised by a series of limestone plateaus (adjacent to the gas export pipeline corridor) separated by channels, and to the west of Cape Helvetius on the south-west corner of Bathurst Island (approximately 10 km from the gas export pipeline corridor). While the gas export pipeline route is still subject to detailed engineering, and further refinement, the alignment will look to avoid these features wherever technically possible.

The shelf areas were characterised by plateaus (i.e. terraces and banks) and channels of varying depths and slope aspects with strong tidally driven currents contributing to turbid water conditions over the ridges and valleys (Heyward et al. 2017). The turbid waters associated with the shelf areas significantly reduced light attenuation and, therefore, limited the amount reaching the seabed. The initial review of the water column light profiles indicated progressive drops in water clarity from the outer shelf shoals shorewards, with surface light attenuating to < 5% at approximately 45 m deep on the shoals, 30 m near Goodrich Bank and 10 m near Cape Helvetius (Heyward et al. 2017). As a result of the reduced light attenuation, the shelf areas typically had large areas of bare seabed with the benthic communities present dominated by sparse patchy sessile filter feeders that were associated with limited areas of consolidated substrate (sandy pavement or minor rocky outcrops). Phototrophic species such as hard corals were rare and only encountered on the shallowest survey transects (depths less than 30 m) near Goodrich Bank (Heyward et al. 2017). Macroscopic biota was generally sparse, however, low to medium density filter feeder habitats were encountered in both the Goodrich Bank and Cape Helvetius areas **(Figure 5-10**). Sponges tended to be the dominant fauna, as consistent with other studies in turbid shelf areas in this region, with various small to medium sized soft corals contributing to a small portion of the mixed filter feeder communities.



(source: North West Atlas 2017)

Figure 5-8: Benthic habitat of the Oceanic Shoals marine park as modelled by AIMS (http://northwestatlas.org/ node/1710)

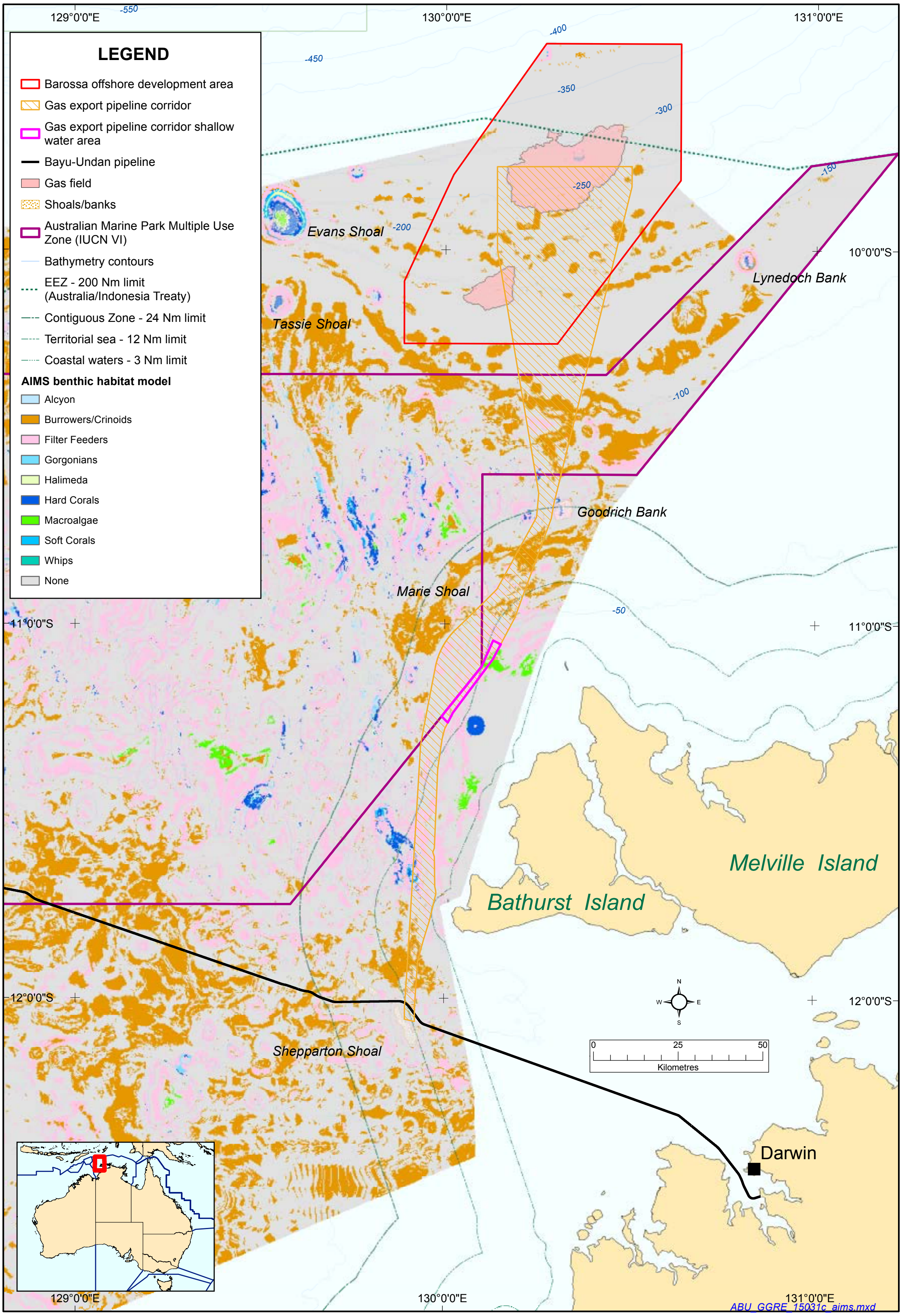
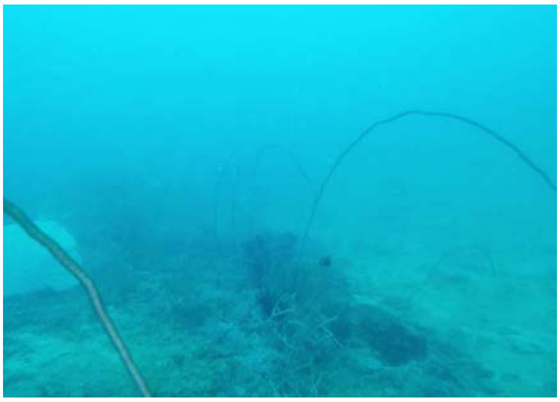


Figure 5-9: Benthic habitat of the Oceanic Shoals marine park and surrounds (extended model) as modelled by AIMS

a) Coarse sandy substrate with sparse filter feeders

b) Hard coral habitat at 25 m depth



c) Medium density mixed filter feeder community associated with patches of low relief outcropping rock

Figure 5-10: Benthic habitats associated with the mid-shelf area near Goodrich Bank

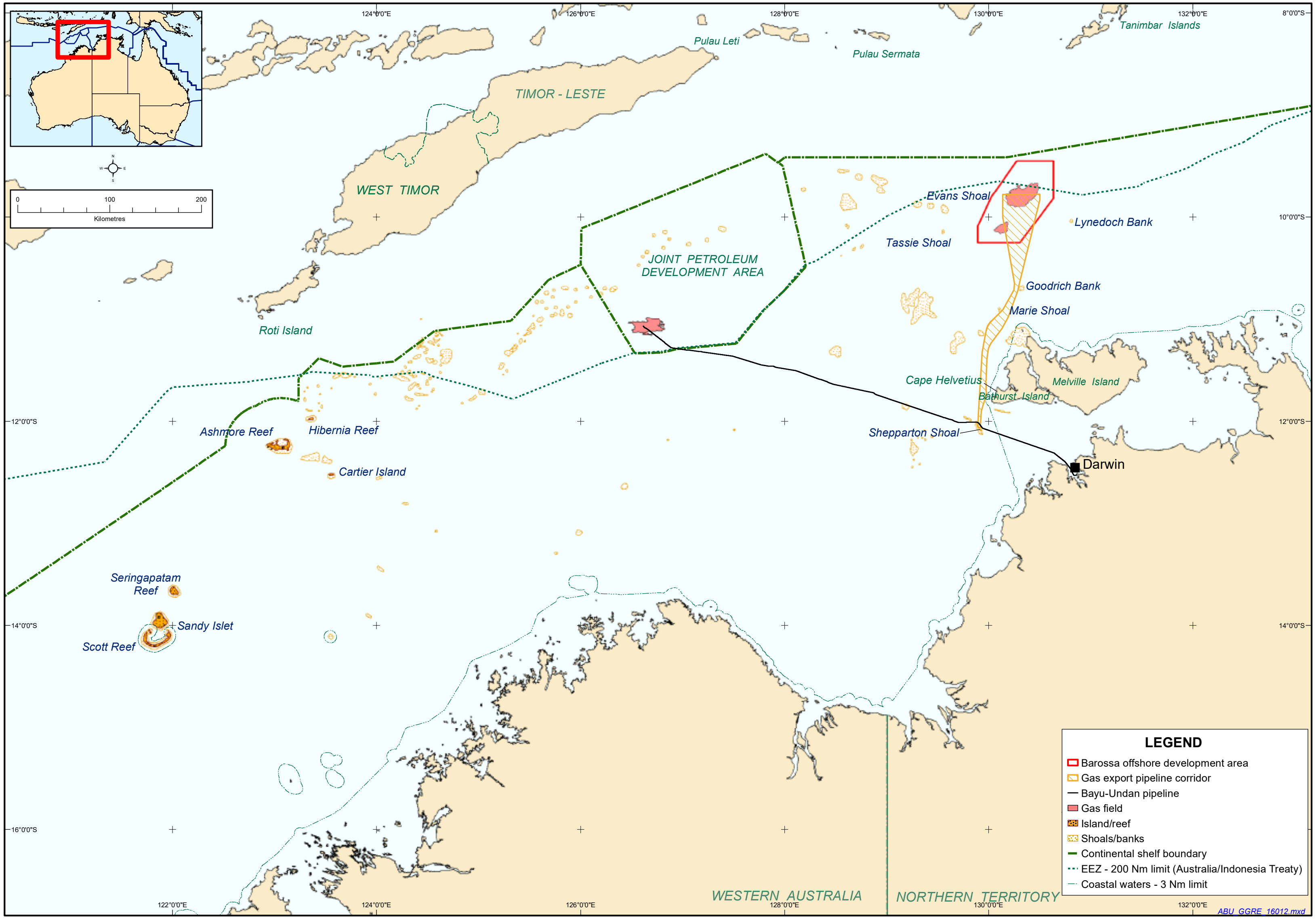


Figure 5-11: Regionally important shoals, banks, reefs and islands in the Timor Sea

5.5.3 Regionally important shoals and banks

Key regionally important environmental features are shown in **Figure 5-11**. The shoals and banks that are of relevance to the project area are described in **Section 5.5.3.2** (Barossa offshore development area) and **Section 5.5.3.3** (gas export pipeline corridor). An overview of those that occur within the area of influence are summarised in **Section 5.5.3.1**, with those that were assessed for exposure from hydrocarbons as a result of unplanned events presented in **Appendix L**.

5.5.3.1 Regional overview

There are a number of shoals and banks in the Timor Sea and open offshore waters. Historically, few studies have been undertaken of these features with the majority of the understanding derived from the Big Bank Shoals study (Heyward et al. 1997) and PTTEP surveys initiated in response to the Montara incident (Heyward et al. 2010; Heyward et al. 2011). The regional shoal survey effort undertaken by AIMS for the Barossa marine studies program (Heyward et al. 2017; **Appendix F**) has contributed significantly to the understanding of these shoals/banks. As shown in **Figure 5-11** (and discussed in Heyward et al. 2017 (**Appendix F**) and **Appendix L**) there are various shoals/banks present within the area of influence defined for this project.

The shoals/banks in the area of influence share a tropical marine biota consistent with that found on emergent reef systems of the Indo West Pacific region such as Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef (Heyward et al. 2017). There is a high level of interconnectivity between the shoals and banks within the area based on larval development rates of many of the species inhabiting the various shoals and banks, current speeds (commonly 20 km–30 km/day in mild weather) and the distance between shoals, banks and reefs (Heyward et al. 2017). The distribution of over 150 shoal/bank features across the Sahul Shelf (**Figure 5-11**), with individual shoals/banks often separated by 5 km –20 km, suggests an extensive series of "stepping stone" habitats are available to recruit larvae and connect these ecosystems at ecological time scales (Heyward et al. 2017). This region also sits within the strong ITF, providing a source of larvae from tropical benthic habitats within the region.

An analysis, undertaken by AIMS, of benthic communities surveyed in the Barossa marine studies program showed that neighbouring shoals and banks (i.e. within 100s of km's) frequently share approximately >80% of benthic community composition (Heyward et al. 2017). The most influential determinants of the benthic community composition observed to date include depth and light intensity, substrate type and complexity, hydrodynamic environment and position on the continental shelf (Heyward et al. 2017). In addition, cycles of natural disturbance and subsequent founder effects may also explain some of the variability between shoals (Heyward et al. 2017). Therefore, each of the shoals/banks are likely to have the potential to support the same types of benthic habitats, dependent on extent of these underlying variables with variability driven by variation in the dominance of key habitats and species (Heyward et al. 2017). Some shoals/banks may be notable for the abundance of particular biota (in terms of species abundance and relative contribution key taxa make to the benthic community), but that status can be dynamic with a large number of common species being shared in common across the region (Heyward et al. 2017). While temporal datasets for the region's shoals and banks are limited, observed changes from year to year are consistent with responses to natural disturbances such as thermal stress events, storms and cyclones (**Appendix F**).

Therefore, at the regional scale, the shoals and banks all support comparable levels of biodiversity, but may vary in the abundance and diversity of dominant benthic species, with subsets of species featuring more prominently on some than others (Heyward et al. 2017). Similarly, the associated fish fauna is highly diverse but variable between shoals and banks, being influenced by depth, substrate and exposure to prevailing weather, though with all shoals/banks sharing many species (Heyward et al. 2017).

The submerged features within the area are characterised by abrupt bathymetry, rising steeply from the surrounding outer continental shelf at depths of 100 m–200 m. The shoals and banks tend to flatten at depths of 40 m–50 m, with horizontal plateau areas of several square kilometres generally present at 20 m–30 m depths (Heyward et al. 2010). The shoals/banks support a diverse and varied range of benthic communities, including algae, reef-building soft corals, hard corals and filter-feeders (Heyward et al. 1997; Heyward et al. 2011). Heyward et al. (2017) reported that bare sand and consolidated reef, often supporting turfing algae, are major features of all shoals in the Timor Sea. It was also noted that hard corals and macroalgae, while ubiquitous, were variable in abundance with soft corals and sponges often forming key components of the benthos (Heyward et al. 2017). The plateau areas are generally dominated by BPPH, with interspersed areas of sand and rubble patches (Heyward et al. 2011).

The submerged shoals/banks support biologically diverse fish communities, with many of the species also known from other emergent reefs in the NWMR, including Ashmore Reef, Cartier Island, Seringapatam Reef and Scott Reef (Heyward et al. 2011). Fish species richness commonly increases with reef structure (i.e. coverage of calcareous reef) with fish diversity generally higher on the tops of the shoals/banks when compared to the rim habitats. The number of fish communities appears to correspond with the size of the shoal/bank as the larger shoals were inhabited by more communities (Heyward et al. 2011).

5.5.3.2 Shoals and banks in the vicinity of the Barossa offshore development area

Summary overview

While other shoals (e.g. Blackwood Shoal), banks and seabed features of interest were surveyed as part of the Barossa marine studies program, the shoals and banks of most relevance to this OPP due to their closest proximity to the Barossa offshore development area (i.e. Evans Shoal, Tassie Shoal and Lynedoch Bank) are described below. In summary, analysis of the results from the Barossa marine studies program showed a high degree of similarity between the sites at these shoals/banks, based on the consistent diversity observed in habitat features and biota present. One exception to this was the eastern slope of Evans Shoal, which showed a higher degree of similarity to a scarp feature (**Section 5.5.3.3**) (Jacobs 2016c). This may be due to depth or greater exposure to predominant currents and weather.

In general, the reef flat at Evans Shoal was characterised by sand and algae-covered rubble with communities dominated by hard corals, soft corals, various algae and sponges which were present in varying degrees of diversity and abundance (Jacobs 2016c, Heyward et al. 2017). The plateaus of Evans Shoal and Tassie Shoal also had extensive areas of sand and rubble (Heyward et al. 2017). Gorgonians and sea whips often dominated the reef crest, whereas the hard substrate of the slope predominantly supported sponges and filter feeders (such as gorgonians, feather stars, sea whips). Filter feeders became more prevalent on rocky outcrops beyond approximately 60 m (Heyward et al. 2017). Of particular note were the northern and southern slopes of Evans Shoal as they supported large areas of dense plate coral (at 40 m–50 m water depth) and dense sub-massive coral (northern slope at approximately 47 m water depth) (Jacobs 2016c).

Heyward et al. (2017) also recorded areas of medium to high density foliaceous coral at Evans Shoal and Tassie Shoal and noted that this habitat was very similar to that observed further west in the Sahul Shoals and within the deeper lagoon at Scott Reef. Overall coral cover of approximately 9% was observed at both Evans and Tassie Shoals (Heyward et al. 2017). An interesting feature on both Evans and Tassie Shoals was the presence of single large bommies of the coral *Pavona clavus*.

The AIMS survey reported that the benthic habitats at Evans Shoal and Tassie Shoal appeared to be in healthy condition, although there was a notable lack of giant clams (only two were observed from the transects) (Heyward et al. 2017). While the detectability of clams using towed video is unknown, their general absence may be a result of illegal fishing practices in the area. With the exception of the lack of clams, there was little or no mortality observed amongst coral species with the presence of large table corals suggesting no recent major disturbances from storms (Heyward et al. 2017).

Heyward et al. (2017) noted that the seabed habitats present at the shoals were broadly consistent with those observed from studies across the region. It was also noted that while there are many similarities between the shoals in the region, there are differences, which may be the result of the broader physical environment. For example, the status of the benthic communities on each shoal may reflect different disturbance events (e.g. cyclone/storm damage and coral bleaching) and recruitment histories due to variations in biological connectivity (Heyward et al. 2017). While the levels of ecological connectivity among the shoals remain to be demonstrated, strong surface currents tracked using satellite drifters throughout this bioregion indicate transport rates of 20 km/day under light to moderate wind conditions and much higher during storms or seasonal trade wind periods (Heyward et al. 2017). Consequently, connectivity between shoal features is expected (Heyward et al. 2017).

The slopes supported a diverse range of fish species typical of reef-fish assemblages as well as pelagic species. Species richness in the fish community was influenced most by the calcareous reef composition of the substrata, and the percentage cover of hard coral on this substratum type (Heyward et al. 2017). Therefore, species richness decreased with depth as seabeds exhibited bare substrata. Detailed characterisation of the fish communities at Evans Shoal and Tassie Shoal were undertaken by AIMS with a summary of the findings presented in **Section 5.6.5.3**. White tip reef and silvertip sharks were also observed at the shoals/banks (Jacobs 2016c).

The AIMS survey of Evans and Tassie Shoal also observed four species of shark (silvertip shark, reef shark, white tip reef shark and tawny nurse shark), none of which are listed under the EPBC Act, and three species of sea snake (olive sea snake, turtle-headed sea snake and an unidentified species) (Heywood et al. 2016).

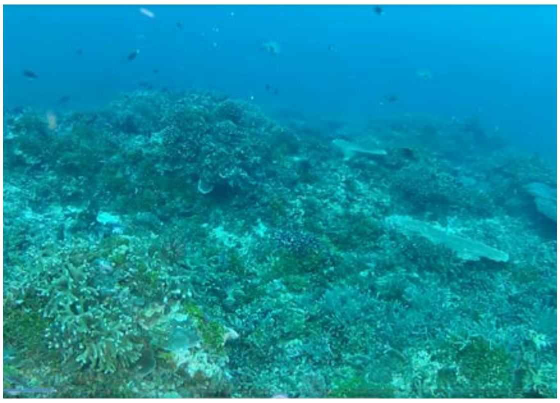
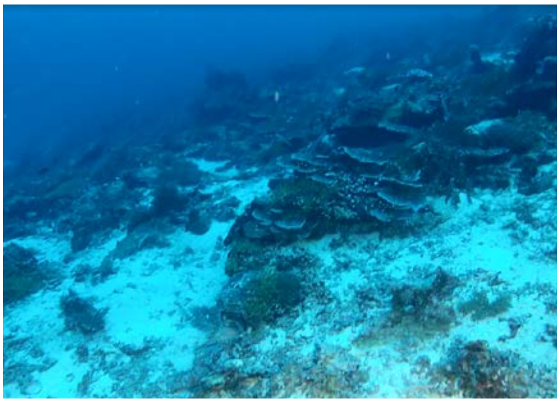
Evans Shoal

Evans Shoal, located approximately 35 km to the west of the Barossa offshore development area, is a flat topped shoal that reaches a plateau at approximately 18 m–28 m below the sea surface.

The infauna communities were reasonably diverse and abundant (3 to 63 individuals representing 3 to 42 taxa in the coarser sediments) with species present being dominated by molluscs (e.g. laevidentaliidae), crustaceans (e.g. tanaids, amphipods, isopods, callianassids) and annelid worms (e.g. syllids, *Nematonereis* species, lumbrinerids) (Jacobs 2016b). The coarser sediments at Evans Shoal supported higher species diversity and abundance. The relationship between coarse sediments, high infaunal abundances and species richness has been previously identified in the north-west shelf with Huang et al. (2013) noting that greater species richness and total abundance were associated with coarse-grained, heterogeneous sediments (cited in Jacobs 2016b).

The key benthic habitats and dominant fish species associated with the shoal are discussed below (Jacobs 2016c).


a) *Reef flat (centre of the shoal)*: The transect was located at a water depth of approximately 28 m. The substrate was predominantly sand with patchy mixed beds of filter feeders (e.g. sponges and soft corals) and macroalgae. Hard corals were observed at a small bommie (Jacobs 2016c). Heyward et al. (2017) noted that hard corals were generally sparse or absent across large areas of the plateau, however, their density increased towards the outer edges of the plateau. Several taxa of fish including species from families Labridae, (wrasse), Pomacanthidae (damselfish and clownfish), Acanthuridae (surgeonfishes, tangs and unicornfishes), Zanclidae (Moorish idols), Balistidae (triggerfishes) and Monacanthidae (leatherjacket).

b) *Southern slope*: Transects on this slope commenced on the reef flat in 18 m water depth. While the substrate of the reef flat was dominated by sand and rubble, some areas supported high-density coral cover (mostly plate and branching forms but also soft corals) and Halimeda species (calcareous algae). A diverse assemblage of reef-fish occurred in these areas and whitetip reef sharks were also observed. The reef crest of the shoal (approximately 32 m deep) was dominated by plate coral, whereas the upper slope was dominated by sand. As water depth increased the substrate changed from being dominated by plate corals (approximately 42 m depth) to macroalgae with scattered sponges and sea cucumbers (approximately 55 m depth).


c) *Eastern slope*: Transects on this slope began at approximately 83 m water depth. The reef flat was characterised by sandy substrate with occasional small macroalgae. Silvertip sharks were observed in this habitat. The crest of the shoal (approximately 88 m deep) supported a rocky overhang with various types of filter feeders. The slope was dominated by steep rock faces and rocky overhangs with small sandy ledges which supported filter feeders (such as gorgonians, feather stars, sea whips, sponges) and reef-fish.

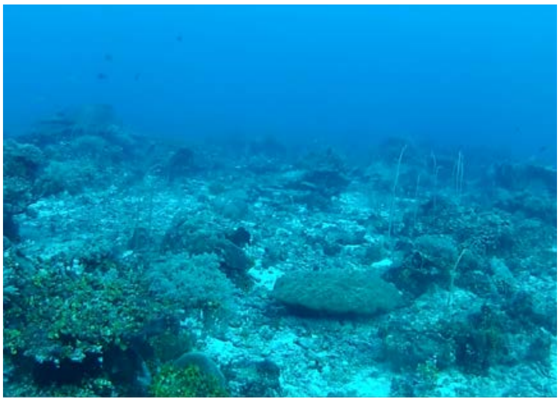
d) *Northern slope*: Transects on the northern slope began at approximately 45 m water depth. The reef flat on this slope alternated between areas dominated by plate coral, sub-massive coral and macroalgae (including *Halimeda* species) with sponges. Whitetip reef sharks and one tawny nurse shark were observed on the reef flat as were representatives from the fish families Labridae, Pomacentridae and Pomacanthidae. Small discrete piles of rubble were also observed and were likely to be triggerfish nests. The crest of the shoal (approximately 80 m deep) was colonised by sponges, filter feeders and algae. The reef slope was characterised by rocky substrate with small sand-covered ledges and supported communities dominated by sponges and filter feeders (such as gorgonians, feather stars, sea whips, sponges). One moray eel (Muraenidae) and various species of fish (families Chaetodontidae (butterflyfish), Carangidae (queenfishes, runners, scads and trevallies), Caesionidae (fusiliers), Serranidae (groupers and reef cod) and Holocentridae (squirrelfish)) were observed in the rocky overhangs of the reef slope.

Tassie Shoal

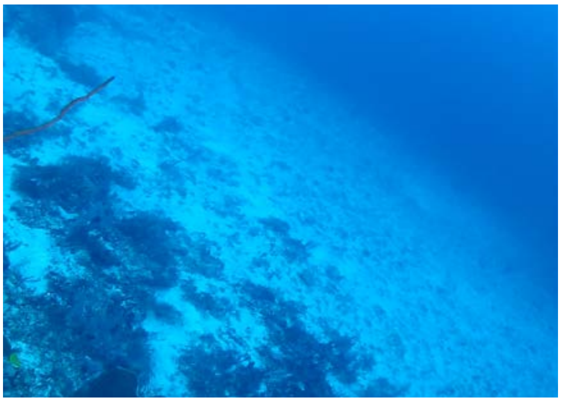
Tassie Shoal, located approximately 32 km to the west of the Barossa offshore development area, is a flat topped shoal that reaches a plateau at approximately 14 m–15 m below the sea surface.

The infauna communities were reasonably diverse and abundant (12 to 33 individuals representing 12 to 24 taxa), with species present being dominated by syllid polychaetes, tanaid crustaceans, foraminifera, brittlestars and fibularid echinoderms (urchins) (Jacobs 2016b).

The key benthic habitats and dominant fish species associated with the shoal are discussed below (Jacobs 2016c).



a) *Reef flat*: The reef flat was sampled at two sites at a water depth of approximately 15 m. The substrate consisted of sand, rubble and patchy reef structure. The reef structure was dominated by massive, sub-massive, plate and branching coral forms, and the hard substrate supported a range of sea whips, soft corals, *Halimeda* species, turf algae and sponges. Feather stars, large clams and a decapod crustacean were also recorded. A diverse range of tropical fish species were sighted including representatives from the families Labridae, Pomacentridae, Zanclidae, Pomacanthidae and Acanthuridae. Two whitetip reef sharks were also observed.



b) *Eastern slope*: The transect began in approximately 28 m water depth. The reef crest was dominated by hard coral, soft coral and sponges, but also supported *Halimeda* species. Schools of fish (Acanthurids and Carangids), sea snakes were observed on both the reef flat and upper slope. The top of the reef slope (30 m–50 m) was dominated by sponges and soft corals, such as gorgonians and sea whips. The substrate became dominated by sand and rock at approximately
50 m and began to flatten out and become dominated by sand around 70 m. A sea snake and a whitetip reef shark were observed at the bottom of the reef slope (approximately 48 m).

Lynedoch Bank

Lynedoch Bank, located approximately 27 km to the east of the Barossa offshore development area, is a flat topped bank which reaches a plateau at approximately 14 m–16 m below the sea surface.

The infauna communities were reasonably diverse and abundant (56 individuals representing 39 taxa) with species present being dominated by nematodes, tanaid crustaceans, and polychaetes (tube-dwelling onuphids and chaetopterids, and lumbrinerids), brittlestars (ophiuroids) and mud shrimp (callianassids) (Jacobs 2016b).

The key benthic habitats and fish communities of the shoal are discussed below (Jacobs 2016c).

a) *Reef flat (centre of the shoal)*: The reef flat was sampled at two sites at a water depth of approximately 16 m. The reef flat was dominated by sand and rubble with hard corals (mostly branching, massive and sub-massive), sponges, soft coral and *Halimeda* species present. Small reef-fish were common (including representatives of the families Chaetodontidae, Labridae and Zanclidae) with whitetip reef sharks, a sea snake and a moray eel also observed.

b) *Eastern slope*: The transect began on the reef flat in approximately 26 m water depth, which was observed to be similar to that described above. The reef sloped gently to a depth of approximately 85 m and was characterised by a sand and rubble substrate. There was a noticeable low abundance of fish, sharks and other motile biota.


c) *Western slope*: The transect began on the reef flat in a water depth of approximately 20 m. The reef flat was characterised by sand and rubble with hard corals (mostly branching, encrusting and massive forms), sponges and *Halimeda* species present. Small triggerfish (Balistidae) were common with sharks (most likely silvertip and whitetip reef sharks) and a sea snake also observed. The reef crest (approximately 40 m water depth) and the slope were dominated by sand and rubble, with occasional sponges, sea stars, sea cucumbers, and reef-fish (Pomacanthidae). The slope flattened out at approximately 70 m deep and became dominated by sand.

5.5.3.3 Shoals and banks within the vicinity of the gas export pipeline corridor

Goodrich Bank, Marie Shoal and Shepparton Shoal

Goodrich Bank, Marie Shoal and Shepparton Shoal are located directly adjacent to the gas export pipeline corridor.

As discussed in **Section 5.5.2.2**, AIMS undertook a seabed biodiversity survey in 2015 at two mid-shelf seabed locations adjacent to Goodrich Bank and Cape Helvetius (Heyward et al. 2017). The survey findings can be used to provide some insight into the potential types of benthic habitats that may occur at the shoals/banks closest to the gas export pipeline. The benthic habitat surrounding Goodrich Bank supported sparse to moderate density filter feeders (dominated by small sponges) on areas of bare rock or sand covered pavement, with larger organisms observed on outcropping low relief reef or rocks. Hard corals were rare in the waters surrounding Goodrich Bank and were only encountered at depths less than 30 m. The extended benthic habitat map produced by AIMS suggests that benthic communities at Goodrich Bank are dominated by filter feeders, with areas of hard corals, gorgonians, burrowers/crinoids and alcyons (**Figure 5-9**).

A survey was undertaken in 2010 by Geoscience Australia and AIMS to map the seabed environments of the Van Diemen Rise (Anderson et al. 2011). The survey involved towed-video transects at 77 sites to characterise the benthic habitats and epibenthos in the four geomorphic environments (banks, terraces, valleys and plains) within the Van Diemen Rise survey area (784 km^2). The shallow banks sampled within the contained complex benthic features with diverse and often dense epibenthic assemblages. A total of 175 video characterisations were recorded from 13 bank sampling sites in the study area and sampled from depths of 10.5 m–54.3 m (mean depth of 34 m). The sites were characterised by mostly low-lying rock outcrops that supported dense and diverse habitat (Anderson et al. 2011). Benthic assemblages observed on these outcrops included hard corals (18% occurrence; recorded only in shallow waters (<35 m) and included reef-building plating and branching corals), sponges (87% occurrence; dominated by fan, branching and digitate growth forms) and octocorals (99% occurrence; dominated by whips, hydroids and soft corals), along with smaller colonies of bryozoa and ascidians (Anderson et al. 2011). The rocky outcrops were interspersed by small areas of coarse-grained soft sediments that were relatively barren and supported few organisms (Anderson et al. 2011).

The AIMS extended benthic habitat map shows that burrowers/crinoids and filter feeder communities are expected at Marie and Shepparton Shoals (**Figure 5-9**).

As discussed in **Section 5.5.3.1**, connectivity between shoal features is expected given the strong surface currents experienced by the region (Heyward et al. 2017). Therefore, it is anticipated that the ecological characteristics of the Goodrich Bank, Marie Shoal and Shepparton Shoal are broadly consistent with the above description of the shoals and banks located within the vicinity as well as the characteristics described for Evans Shoal, Tassie Shoal and Lynedoch Bank.

5.5.4 Regionally important offshore reefs and islands

This section discusses those offshore reefs and islands that occur within the area of influence.

Ashmore Reef

Ashmore Reef lies approximately 750 km to the south-west of the Barossa offshore development area and is protected by the Commonwealth managed Ashmore Reef National Nature Reserve (**Section 5.7.2**) and Ashmore Reef marine park (**Section 5.7.6**). Ashmore Reef is also a designated Ramsar wetland of international significance (**Section 5.7.4**).

Ashmore Reef is a large platform reef of 227 km^2, consisting of an atoll-like structure with three low, vegetated islands, numerous banks of shifting sand and two large lagoon areas. The surrounding reef consists of a well-developed reef crest — most prominent on the south and east sides — and a broad reef flat that can be up to 3 km across. Along the edge of this reef flat area are large areas of drying sand that become exposed at low tide, particularly along the southern side. Water depth within the lagoon is highly variable, ranging from extremely shallow around the sand banks and up to 45 m in the deeper areas. The three islands located within the lagoon — West Island (281,000 km^2), East Island (134,200 km^2), and Middle Island (129,800 km^2) — are mostly flat, being composed of coarse sand with a few areas of exposed beach rock and limestone outcrops (Clarke 2010; Shell 2009).

Cartier Island

Cartier Island lies approximately 735 km to the south-west of Barossa offshore development area. The island and surrounding reefs are protected by Cartier Island marine park (**Section 5.7.6**). Cartier Island is an un-vegetated sand cay surrounded by mature reef flats; it sits at the centre of a reef platform that rises steeply from the seabed. The island is composed of coarse sand and is stabilised by patches of beach rock around its perimeter. The island supports large populations of nesting marine turtles.

Hibernia Reef

Although part of the same group as Ashmore Reef and Cartier Island, Hibernia Reef does not form part of the Ashmore Reef and Cartier Island External Territory of Australia. Hibernia Reef is approximately 740 km to the south-west of Barossa offshore development area and is situated approximately 40 km north-east from Ashmore Reef and 60 km north-west of Cartier Island. Hibernia Reef consists of an approximately oval-shaped reef that tapers to a point on the western side. The reef covers an area of approximately 11.5 km^2 and has no permanent land, but large areas of the reef can become exposed at low tide. Hibernia Reef is also characterised by a deep central lagoon and drying sand flats.

Seringapatam Reef

Seringapatam Reef (approximately 960 km to the south-west from the Barossa offshore development area) is a remote atoll covering an area of approximately 55 km^2 and encloses a lagoon of relatively consistent depth of approximately 20 m (maximum depth of 30 m) (Heyward et al. 2013). The lagoon is connected to the ocean by a narrow passage in the northeast part of the reef.

Seringapatam Reef is recognised as a KEF (**Section 5.7.8**). The reef is a regionally important scleractinian coral reef as it has a high biodiversity, which is comparable to Ningaloo Reef (Heyward et al. 2013). Results from the Western Australian Museum (WAM) survey in 2006 noted 159 species of scleractinian corals with a hard coral cover of approximately 16% (WAM 2009). A 2010 survey by Heyward et al. (2010) on the condition of shallow reef communities at Seringapatam Reef noted that the coral cover on slopes (20–25%) and reef flats (< 10%) to be similar to Ashmore Reef and Cartier Island surveyed in the same study.

ConocoPhillips commissioned a number of baseline studies at Seringapatam Reef in 2013, as part of their interests in the Greater Poseidon Field in the Browse Basin, to understand the characteristics of the benthic habitats and fish communities. The dominant benthic habitats of the reef were observed to include turf algae, macroalgae, hard and soft corals, algae and filter feeders (e.g. sponges, gorgonians, hydroid, seapens) (Heyward et al. 2013).

Scott Reef

Scott Reef (approximately 970 km to the south-west from the Barossa offshore development area) includes North Scott Reef and South Scott Reef. North Scott Reef is an annular reef, approximately 17 km long and 16 km wide, enclosing a shallow lagoon (up to 20 m deep) that is connected to the ocean by passages in the north-east and south-west (Gilmour et al. 2013, Woodside 2014). South Scott Reef is a crescent-shaped reef that is approximately 20 km wide. The lagoon at South Scott Reef ranges in depth (20 m to 70 m) and support significant benthic communities such as hard and soft corals. Sandy Islet, to the north of South Scott Reef, represents the only sandy shoreline habitat at Scott Reef and is a significant nesting site for green turtles, predominantly during the summer months (Gilmour et al. 2013).

Scott Reef is recognised as a KEF (**Section 5.7.8**). Corals communities at Scott Reef occur across shallow (< 30 m) and deep (> 30 m) habitats, with 306 species from 60 genera and 14 families having been identified (Gilmour et al. 2009). Coral communities varied from shallow to deep water with 295 species recorded from shallow water environments and 51 species from deep water. Eleven species were only found in deep water environments. Of the corals recorded, none were endemic to Scott Reef (Gilmour et al. 2009) and all predominantly widespread Indo–Pacific species.

Tiwi Islands

The Tiwi Islands are situated approximately 80 km north of Darwin and are comprised of Melville Island, Bathurst Island, and nine smaller uninhabited islands off the northern and southern shores. The Tiwi Islands are approximately 100 km south of the Barossa offshore development area and approximately 6 km east of the gas export pipeline corridor (closest point). The islands cover an area of approximately 8,320 km^2 and support a number of important habitats, including extensive stands of mangroves, tidal mudflats, sandy beaches, seagrass meadows and fringing reef habitats (INPEX 2010). Many species found on the islands are not recorded anywhere else in the NT, primarily due to their isolation and climatic extremes (high rainfall) (Department of Natural Resources, Environment, The Arts and Sport (NRETAS) 2009a). The Tiwi Islands are Aboriginal freehold land owned by the Tiwi Aboriginal Land Trust (NRETAS 2009a).

The Tiwi Islands, and small islands in the vicinity, support important nesting sites for marine turtles, internationally significant seabird rookeries, and some major aggregations of migratory shorebirds (DLRM 2009). The sandy beaches on the Tiwi Islands, specifically the west coast of Bathurst Island and the north coast of Melville Island, are particularly important for marine turtle nesting. Nesting is dominated by flatback and olive ridley turtles (Chatto and Baker 2008). However, green and hawksbill turtles also nest on the Tiwi Island. Significant numbers of olive ridley turtles are known to nest on the beaches of Seagull Island and the north-west coast of Melville Island (Chatto and Baker 2008). The DoEE National Conservation Values Atlas (DoEE 2017c) shows a number of biologically important areas for turtles surrounding the Tiwi Island coastline (**Section 5.6.3**).

Five seabird breeding colonies have been reported on small offshore islands surrounding Melville and Bathurst Islands (Chatto 2001) that range in size from two to over 30,000 birds (Chatto 2001). The colony on Seagull Island, off the north-west tip of Melville Island, supports a BIA of approximately 60,000 crested terns (Woinarski et al. 2003), which is thought to be the largest breeding colony of this species and is considered an internationally significant colony (> 1% global population) (NRETAS 2009a). A 20 km buffer has been designated around the BIA as a foraging zone for the crested terns (see **Section 5.6.4.2**). The breeding period for the crested tern is from March to July, with most eggs being laid between from late April to early June (Chatto 2001). In general, colonial seabird breeding in the NT occurs throughout most of the year, though mostly between May and November (Chatto 2001). The extensive areas of tidal flats, particularly on the south-east of Melville Island, have also been noted as providing important wading and feeding habitats for shorebirds. The highest total count at this site was 40,000 shorebirds in 1993 with the most common species being Great Knots (Chatto 2003). Other species recorded in high numbers include red-necked stints, greater and lesser sand plovers and bar-tailed godwits (Chatto 2003).

The north coast of the Tiwi Islands is recognised as a key site for the conservation of dugongs (Parks and Wildlife Service NT (PWSNT) 2003). Further discussion of the presence of dugongs in the vicinity of the Tiwi Islands is provided in **Section 5.6.2.2**.

The Australian snubfin dolphin (*Orcaella heinsohni*), listed as migratory under the EPBC Act, has been sighted in waters in close proximity to the Tiwi Islands and NT/WA coastline. Further discussion of the species is provided in **Section 5.6.2.2**.

5.5.5 Other regional seabed features of interest

Seamounts

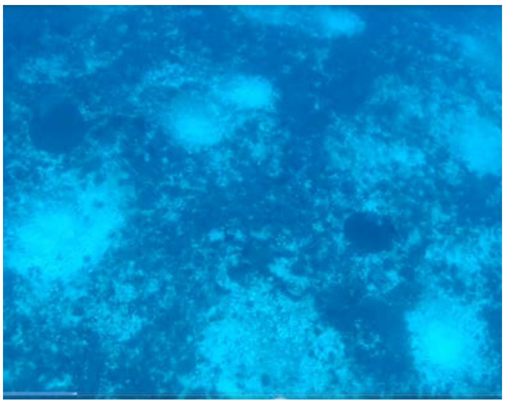
The Barossa marine studies program included sampling sites at several seamounts in the broader vicinity of the Barossa offshore development area (within approximately 9 km–18 km to the west). The seamounts are generally raised up from the seabed to water depths between 50 m and 80 m and are characterised by predominantly sand and rubble (Jacobs 2016c). The hard substrate of the seamount slopes supported epibenthic communities dominated by sponges and filter feeders such as gorgonians (e.g. sea whips, sea fans and soft corals) and feather stars. Other epibenthic species observed included holothurians (sea cucumbers), sea fans and algae (Jacobs 2016c). Representative images of the seamounts are shown in **Figure 5-12**.

Triggerfish nesting areas were apparent at the seamounts. The triggerfish (family Balistidae) appeared to make depressions in the sand and rubble at the top of the southernmost seamount surveyed as they were observed in and around these depressions (Jacobs 2016c). At a seamount directly west of the Barossa offshore development area (approximately 18 km), small discrete piles of rubble had been accumulated that also may have been fish nests or as the result of tidal/current movement. These piles were also observed on the northern slope of Evans Shoal. The seamounts also appeared to support schools of fish (predominantly from families Lutjanidae, Carangidae and Caesionidae, and including larval or juveniles) both near the top of the seamount and at depth. Goldband snapper individuals were tentatively identified at depth at seamount sites, with one individual also observed at the scarps south of the Barossa offshore development area. Silver tip sharks, a sea snake (unidentified species) and small ray were also observed at the seamounts.

Four grey nurse sharks were observed at one of the seamounts in approximately 130 m–160 m water depth, including at least one female that appeared to be pregnant. This was considered unusual as neither the east or west coast populations are known to extend that far north and are generally associated with shallower, more coastal waters (DoEE 2017e). However, a paper published in March 2015 recorded four grey nurse sharks (three females and one male) being caught in the vicinity of Browse Island (approximately 800 km south-west of the Barossa offshore development area) and described this catch as the first known from the Timor Sea (Momigliano and Jaiteh 2015, cited in Jacobs 2016c). It is unknown whether the individuals observed during this survey would be linked to the east (listed as critically endangered) or west coast (listed as vulnerable) populations, or another discrete population.

a) Substrate with soft coral (gorgonians) and feather star

b) Triggerfish on rocky substrate



c) Distribution of triggerfish nests in the sand and rubble substrate near the top of the seamount

d) Boulders at the base of the slope with a squirrel fish (family Holocentridae)

Figure 5-12: Seamount benthic habitat and communities

Scarps

The Barossa marine studies program included sampling sites at two scarps in the Barossa offshore development area (between the Barossa Field and Caldita Field), which were in water depths ranging between 160 m and 190 m. The substrate of the scarps was similar and characterised by a hard bedrock pavement at the top, with a rocky profile along the ridge and sand habitats at the base (Jacobs 2016c). The scarps provided habitat for gorgonians (e.g. sea whips), feather stars and other filter feeders, sponges, and hydroid/bryozoan turf. A deep-water snapper species (possibly goldband snapper) was also observed in a rocky overhang at the base of the slope and small silver fish and one ray were observed on the sand flat at one of the scarps (Jacobs 2016c). Representative images of the scarps are shown in **Figure 5-13**.

a) Rocky substrate covered with silty sand with gorgonians and other filter feeders on the high side of the scarp

b) Rocky scarp profile with filter feeders

Figure 5-13: Scarp benthic habitat and communities

5.5.6 NT and WA mainland coastline

The summary of key regional values and sensitivities provided in preceding sections is focused on the primary features of relevance to the project area – namely the submergent shoals and banks, emergent reefs, and islands that have recognised conservation value.

The NT and WA mainland coastline is only relevant to the project in the context of the area of influence, as some areas of the coastline may be contacted in the unlikely event of a large-scale unplanned release scenario (see **Section 6.4.10**). While the modelling presented in this OPP does not predict contact with the WA coastline, high level consideration has been given to the Kimberley coastline for completeness.

In the NT, the Darwin Harbour coastline extends approximately 500 km^2 and feeds estuaries of rivers that drain from the surrounding hinterland during the wet season (INPEX 2010). Approximately 1,000 km^2 of wetlands are present in the surrounding catchments, including Darwin Harbour, which contains 260 km^2 of mangroves (INPEX 2010). In addition to mangroves, the subtidal and intertidal communities in Darwin Harbour include rocky shore, hard coral, filter feeder (primarily soft corals and sponges), macroalgae and sparse seagrass communities (INPEX 2010). The coastline is also characterised by various habitats such as rocky shores and pavements, sand beaches and mud flats (INPEX 2010). The area is also significantly important to the local Larrakia Aboriginal people with cultural connection to the area, as well as for local tourism, recreation and commercial fishing purposes. The attributes of the coastal area of Darwin Harbour and surrounds are representative of the values of the mainland coastline of the NT, as relevant to the area of influence defined in this OPP.

The nearshore and coastal environments of the Kimberley (WA) support a diverse array of marine habitats and communities including coral reefs, sandy beaches, rocky shores, seagrass meadows, mangroves, sponge gardens, wetlands, estuaries, creeks and rivers (Department of Environment and Conservation (DEC) 2009). The area also provides Indigenous and European heritage value as well as for local tourism, recreation and commercial fishing purposes.

The nearshore and coastal environments of the Kimberley and Darwin Harbour coastlines support EPBC listed protected species including seabirds and migratory shorebirds, turtles, sea snakes, dugongs, dolphins, fish, sharks and rays (DEC 2009, NRETAS 2009b). The environments also provide important habitat for a number of culturally and commercially important marine fauna species such as marine turtles, dugongs, fish and prawns (DEC 2009). Species of conservation significance that occur within the area of influence that intersects with the NT and WA mainland coastline are described in **Section 5.6**. The various Commonwealth Recovery Plans and conservation advices for species of conservation significance present in these areas have been outlined in **Section 3.5.1** and the requirements taken into consideration within the EPBC listed species descriptions in **Section 5.6**.

5.5.7 Plankton

5.5.7.1 Regional overview

Plankton refers to generally passively, mobile, single-celled organisms that are present within the water column. Forms include a highly diverse mix of phytoplankton and zooplankton, ranging in size from micrometres to centimetres that fulfil a diverse range of ecological roles.

Plankton distribution is often patchy and linked to localised and seasonal productivity that produces sporadic bursts in phytoplankton, zooplankton and tropical krill production (DEWHA 2008c). Fluctuations in abundance and distribution occur both horizontally and vertically in response to the tidal cycles, seasonal variation (light, water temperature and chemistry, rainfall, currents and nutrients) and cyclonic events. The seasonal cycles and spatial distribution/abundance of biological productivity still remain largely unknown (DSD 2010). However, in general, the mixing of warm surface waters with deeper, more nutrient-rich waters (i.e. areas of upwelling) generates phytoplankton production and zooplankton blooms.

5.5.7.2 Barossa offshore development area

During the Barossa marine studies program, phytoplankton and zooplankton species were sampled along approximately 300 m long surface water transect tows during the field surveys using plankton nets. Four of the sites were within the Barossa offshore development area (only three of which were sampled in winter), three at Evans Shoal (with only two sampled in winter), three at Tassie Shoal (only one sampled in winter) and two sites at Lynedoch Bank (autumn and summer only) (**Figure 5-2**).

The phytoplankton assemblage composition was relatively similar across the seasons. Diatoms (Bacillariophyceae), blue-green algae (Cyanobacteria) and dinoflagellates (Dinophyceae) were recorded in all seasons, cryptomonads (Crytophyceae) in two seasons (summer and autumn), and silicoflagellates (Dictyochophyceae) and green algae (Chlorophyceae) in only a single season (winter and autumn respectively) (Jacobs 2016a).

Blue-green algae were the most abundant phytoplankton assemblage as they were recorded in approximately 87% of the transect tows and had a mean abundance of approximately 74% across all three surveys. *Trichodesmium erythraeum* (a blue-green alga) was the most abundant phytoplankton species at the majority of sites during each season. *Trichodesmium* species occur in large numbers in tropical areas of the Indian Ocean, where their ability to fix nitrogen enables them to thrive when nutrient concentrations are low (Riley and Chester 1971). Dinoflagellates were the most diverse group during the autumn survey, whereas diatoms were the most diverse group during the summer and winter surveys (Jacobs 2016a).

The zooplankton assemblage composition was relatively similar across the seasons, with summer and winter being most similar (Jacobs 2016a). The summer survey recorded the most diverse assemblage (14 Classes of organisms) while autumn was the least diverse (eight Classes) (Jacobs 2016a). Across all seasons copepods displayed the highest number of different species whereas most other Classes contained only one species (Jacobs 2016a).

5.6 Marine fauna of conservation significance

A summary of the marine fauna of conservation significance identified in the three search areas of the online EPBC Act Protected Matters database is provided below and in **Table 5-4**.

- Barossa offshore development area – the search identified 18 listed threatened fauna species and 29 listed migratory species (17 of which are also listed as threatened species) that may occur or have habitat in the area (DoEE 2017f). All species identified in the Barossa offshore development area were also identified in the gas export pipeline corridor.
- Gas export pipeline corridor – the search identified 20 listed threatened fauna species and 41 listed migratory species (18 of which are also listed as threatened species) that may occur or have habitat in the area (DoEE 2017g). Two threatened species and 10 migratory species were identified in the pipeline corridor in addition to those identified in the Barossa offshore development area.
- Area of influence – the search identified 29 listed threatened fauna species and 71 listed migratory species (21 of which are also listed as threatened species) that may occur or have habitat in the area (DoEE 2017h). Nine mammal, one reptile and seven bird species identified in the EPBC search as threatened species have not been presented in the table below as they are considered not relevant to the project. These species are either terrestrial fauna or threatened bird species that are typically found in habitats distributed on the coastal fringes of Australia, but not necessarily present on shorelines (e.g. wetlands), and/or have not been recorded within the area of influence. Whilst the outer extent of the area of influence does contact some coastal areas (hence flagging these species in the search area), the likelihood of a large-scale spill interacting with these species, given their distribution away from shorelines that may be affected, is remote. Therefore, these species are not discussed further in this report but are listed in **Appendix P** for reference.

The results of the Protected Matters search are summarised in **Section 5.5.1** and presented in **Appendix P**. The listed threatened species and migratory species are described below in the following sub-sections.

Table 5-4: EPBC Protected Matters search results summary for threatened and migratory species

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Cetaceans					
Blue whale (*Balaenoptera musculus*)	Endangered	✓	✓	✓	✓
Humpback whale (*Megaptera novaeangliae*)	Vulnerable	✓	✓	✓	✓
Sei whale (*Balaenoptera borealis*)	Vulnerable	✓	✓	✓	✓
Fin whale (*Balaenoptera physalus*)	Vulnerable	✓	✓	✓	✓
Antarctic minke whale (*Balaenoptera bonaerensis*)		✓	✓		✓
Bryde's whale (*Balaenoptera edeni*)		✓	✓	✓	✓
Killer whale (*Orcinus orca)*		✓	✓	✓	✓
Sperm whale (*Physeter macrocephalus*)		✓	✓	✓	✓
Dugong (*Dugong dugon*)		✓		✓	✓
Australian snubfin dolphin (*Orcaella heinsohni*; formerly known as the Irrawaddy dolphin)		✓		✓	✓
Indo-Pacific humpback dolphin (*Sousa sahulensis*)		✓		✓	✓
Spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*)		✓	✓	✓	✓
Marine reptiles					
Loggerhead turtle (*Caretta caretta*)	Endangered	✓	✓	✓	✓
Green turtle (*Chelonia mydas*)	Vulnerable	✓	✓	✓	✓

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Leatherback turtle (*Dermochelys coriacea*)	Endangered	✓	✓	✓	✓
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable	✓	✓	✓	✓
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered	✓	✓	✓	✓
Flatback turtle (*Natator depressus*)	Vulnerable	✓	✓	✓	✓
Salt-water crocodile (*Crocodylus porosus*)		✓		✓	✓
Short-nosed sea snake (*Aipsurus apraefrontalis*)	Critically endangered				✓
Leaf-scaled sea snake (*Aipysurus foliosquama*)	Critically endangered				✓
Seabirds					
Curlew sandpiper (*Calidris ferruginea*) [1]	Critically endangered	✓	✓	✓	✓
Eastern curlew (*Numenius madagascariensis*) [1]	Critically endangered	✓	✓	✓	✓
Australian lesser noddy (*Anous tenuirostris melanops*)[1]	Vulnerable				✓
Greater sand plover (*Charadrius leschenaultii*)[1]	Vulnerable	✓			✓
Lesser sand plover (*Charadrius mongolus*) [1]	Endangered	✓			✓
Streaked shearwater (*Calonectris leucomelas*) [1]		✓	✓	✓	✓
Common noddy (*Anous stolidus*)[1]		✓	✓	✓	✓
Fork-tailed swift (*Apus pacificus*) [1]		✓		✓	✓
Osprey (*Pandion haliaetus*)		✓		✓	✓
Brown booby (*Sula leucogaster*)[1]		✓			✓
Red footed booby (*Sula sula*)[1]		✓			✓
Greater frigatebird (*Fregata minor*)[1]		✓	✓	✓	✓
Lesser frigatebird (*Fregata ariel*)[1]		✓	✓	✓	✓
Crested tern (*Thalasseus bergii*)[1]		✓		✓	✓
Little tern (*Sterna albifrons*)[1]		✓			✓
Roseate tern (*Sterna dougallii*)[1]		✓			✓

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Wedge-tailed shearwater (*Ardenna pacifica*)[1]		✓			✓
White-tailed tropicbird (*Phaethon rubricauda*)[1]		✓			✓
Western Alaskan bar-tailed godwit (*Limosa lapponica bauera*)[1]	Vulnerable				✓
Northern-Siberian bar-tailed godwit (*Limona lapponica menzbieri*)[1]	Critically endangered				✓
Bar-tailed godwit (*Limonsa lapponica*)[1]		✓			✓
Black-tailed godwit (*Limosa limosa*)[1]		✓			✓
Red-tailed tropic bird (*Phaethon rubricuda*)[1]		✓			✓
Bridled tern (*Sterna anaethetus*)[1]		✓			✓
Masked booby (*Sula dactylatra*)[1]		✓			✓
Barn Swallow (*Hirundo rustica*)[1]		✓			✓
Ruddy turnstone (*Arenaria interpres*)[1]		✓			✓
Sanderling (*Calidris alba*)[1]		✓			✓
Whimbrel (*Numenius phaeopus*)[1]		✓			✓
Grey plover (*Pluvialis squatarola*)[1]		✓			✓
Common greenshank (*Tringa nebularia*)[1]		✓			✓
Great knot (*Calidris tenuirostris*)[1]	Critically endangered	✓			✓
Red knot *(Calidris canutus)*	Endangered	✓		✓	✓
Abbott's booby *(Papasula abbotti)*	Endangered				✓
Sharp-tailed sandpiper *(Calidris acuminata)*		✓		✓	✓
Pectoral sandpiper *(Calidris melanotos)*		✓		✓	✓
Oriental reed-warbler (*Acrocephalus orientalis*)[1]		✓			✓
Red-rumped swallow (*Cecropis daurica*)[1]		✓			✓
Oriental cuckoo (*Cuculus opatus*)[1]		✓			✓
Oriental plover (*Charadrius veredus*)[1]		✓			✓

Species	Threatened status	Listed as migratory	Search area		
			Barossa offshore development area	Gas export pipeline corridor	Area of influence
Oriental pratincole (*Glareola maldivarum*)[1]		✓			✓
Grey wagtail (*Motacilla cinereal*)[1]		✓			✓
Yellow wagtail (*Motacilla flava*)[1]		✓			✓
Common sandpiper (*Actitis hypoleucos*)[1]		✓		✓	✓
Rufous Fantail (*Rhipidura rufifrons*)		✓			✓
Fish					
Whale shark (*Rhincodon typus*)	Vulnerable	✓	✓	✓	✓
Sharks and rays					
Great white shark (*Carcharodon carcharias*)	Vulnerable	✓	✓	✓	✓
Green sawfish (*Pristis zijsron*)	Vulnerable	✓	✓	✓	✓
Largetooth sawfish (*Pristis pristis*)	Vulnerable	✓	✓	✓	✓
Dwarf sawfish (*Pristis clavata*)	Vulnerable	✓		✓	✓
Speartooth shark (*Glyphis glyphis*)	Critically endangered		✓	✓	✓
Northern river shark (*Glyphis garricki*)	Endangered		✓	✓	✓
Narrow sawfish (*Anoxypristis cuspidata*)		✓	✓	✓	✓
Longfin mako (*Isurus paucus*)		✓	✓	✓	✓
Shortfin mako (*Isurus oxyrinchus*)		✓		✓	✓
Reef manta ray (*Manta alfredi*)		✓	✓	✓	✓
Giant manta ray (*Manta birostris*)		✓	✓	✓	✓

[1] These species may be associated with offshore island habitats and have been recorded at Ashmore Reef and Cartier Island (Clarke 2011).

5.6.1 Biologically important areas and habitat critical to the survival of a species

BIAs are defined by DoEE as *"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"* (DoEE 2017c). BIAs provide a tool for defining areas of importance for marine fauna species.

The EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DSEWPaC 2013b) define 'habitat critical to the survival of a species' as areas necessary:

- *"for activities such as foraging, breeding or dispersal;*
- *for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species);*
- *to maintain genetic diversity and long term evolutionary development; or*
- *for the reintroduction of populations or recovery of the species."*

Such habitat may be, but is not limited to, habitat identified in a recovery plan and/or habitat listed on the Register of Critical Habitat, as administered by DoEE.

A review of the DoEE National Conservation Values Atlas (an interactive web-based tool which supports the implementation of Marine Bioregional Plans) in 2017 (DoEE 2017c), prior to the release of the OPP for public comment, identified that the Barossa offshore development area is not located within BIAs for any regionally significant marine species. The gas export pipeline corridor traverses an internesting BIA for flatback turtles and is adjacent to a internesting BIA for olive ridley turtles (**Figure 5-17**). The pipeline corridor also traverses a breeding and foraging area BIA for the crested tern (waters offshore of the Tiwi Islands). The area of influence includes a number of BIAs including foraging areas and internesting areas for marine turtles, a migration corridor for pygmy blue whales, migration area for humpback whales, foraging areas for whale sharks, breeding/foraging/ resting areas for a number of seabird species, and a breeding, calving and foraging area for the Indo-pacific humpback dolphin. The identified BIAs are discussed under the relevant species sections below.

A subsequent review of the DoEE National Conservation Values Atlas was completed in October 2017 (DoEE 2017d) after the completion of the OPP public comment period. In addition to the BIAs discussed above, this review identified that the southern end of the gas export pipeline corridor intersects a portion of the internesting habitat critical to the survival of flatback turtles (Arafura stock) and olive ridley turtles (NT stock) (referred to in the Atlas as 'Habitat Critical (Draft)'). The internesting habitat critical to the survival of these turtle species surrounds the Tiwi Islands and is located immediately seaward of nesting habitat critical to the survival of these species. The internesting habitat critical buffer for flatback turtles and olive ridley turtles is 60 km and 20 km, respectively (DoEE 2017a). For olive ridley turtles, the identified BIA is a subset of the broader habitat critical to the survival of the species, and whilst the pipeline corridor overlaps this habitat critical to the survival of the species, it does not overlap the BIA for olive ridley turtles. The pipeline corridor does overlap both the BIA and habitat critical to the survival of flatback turtles. There is substantial overlap between the internesting BIAs and internesting habitat critical to the survival of flatback and olive ridley turtles. Given this, and the fact that 'habitat critical to the survival of a species' is provided specific consideration in the Recovery Plan for Marine Turtles in Australia (DoEE 2017a) which is a statutory instrument under the EPBC Act, the impact assessment presented in **Section 6** explicitly uses the internesting habitat critical to the survival of flatback and olive ridley turtles as the point of reference to inform the potential risk and impact conclusions.

The Barossa offshore development area does not overlap any habitat critical to the survival of a species.

5.6.2 Marine mammals

5.6.2.1 Regional overview

Marine mammals (cetaceans) are generally widely distributed and highly mobile. In general, distribution patterns reflect seasonal feeding areas, characterised by high productivity, and migration routes associated with reproductive patterns.

Twenty-nine species listed under the EPBC Act (including four threatened and 12 migratory cetaceans), including baleen whales, toothed whales and dolphins, were identified as potentially occurring or having habitat in the area of influence. The four threatened species that may occur in the Barossa offshore development area or gas export pipeline corridor were the blue whale (*Balaenoptera musculus*; endangered), humpback whale (*Megaptera novaeangliae*; vulnerable), sei whale (*Balaenoptera borealis*; vulnerable) and fin whale (*Balaenoptera physalus*; vulnerable).

Of those species identified in the EPBC Protected Matters search, the pygmy blue whale (endangered) and Bryde's whale (migratory) are most likely to occur in the project area. Both species were recorded in the project area during noise monitoring undertaken for the project in 2014/2015 (refer to **Section 5.4.7**). The species of primary relevance, and other species that may traverse through the area, are discussed in detail below.

While not identified in the EPBC Protected Matters search, the Omura's whale (unlisted) is also discussed as the species was observed during the Barossa marine studies program.

5.6.2.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Pygmy blue whale

The blue whale (*Balaenoptera musculus*; endangered) has four distinct sub-species, of which two are found in the southern hemisphere; the pygmy blue whale (Indo-Australian and Tasman-Pacific populations) and the Antarctic blue whale (DoE 2015a). The pygmy blue whale has been recorded in the surrounds of the Barossa offshore development area (JASCO 2016a). Noise monitoring undertaken for the Barossa marine studies program (**Section 5.4.7**) recorded pygmy blue whales moving in a northward direction in August 2014 and between late May and July 2015, as they migrated north towards Indonesian waters (JASCO 2016a). These detections are over approximately 400 km north-east of the BIA associated with the pygmy blue whale migration corridor. No detections of the species were made during the period of their southward migration, indicating that they may utilise a different migration path (JASCO 2016a).

Key aggregation/feeding areas:

- The Perth Canyon off WA, and the Bonney Upwelling System and adjacent waters off Victoria, South Australia and Tasmania are known feeding grounds (**Figure 5-14**; DoE 2015a). These areas are utilised from November to May.
- Pygmy blue whales appear to feed regularly along their migration route (i.e. at least once per week or more frequently) and are likely to have multiple food caches along their migratory route (e.g. Rowley Shoals and Ningaloo Reef) (pers. comm. C. Jenner, CWR, 2014).
- A biologically important foraging area encompasses Seringapatam Reef, Scott Reef and the open waters to the west of these features (**Figure 5-14** and **Figure 5-15**; DoE 2015a; DoEE 2017c. These steep gradient features tend to stimulate upwelling and, therefore increased productivity (seasonally variable) (pers. comm. C. Jenner, CWR, 2014). Hence, they provide a favourable foraging area.

Key migratory pathways/timing:

- At a broader regional scale, the species is known to migrate along the shelf edge at depths between the 500 m and 1,000 m depth contours from the North West Cape south to Geographe Bay (**Figure 5-14**; DoE 2015a).
- A biologically important migration corridor is recognised in deep offshore waters off WA (**Figure 5-15**; DoEE 2017c).
- Northerly migration occurs in March/April to June (migration to the equator calving grounds) (DoE 2015a). The species is more scattered in distribution when migrating northward (pers. comm. C. Jenner, Centre for Whale Research (CWR), 2014).
- Southerly migration occurs in September/October to December (DoE 2015a). Annual acoustic detections of pygmy blue whales at Scott Reef (presumed to be moving south-wards) have been recorded between late October and December (DoE 2015a).
- Generally, they appear to travel as individuals or in small groups based on acoustic data. For example, analysis of pygmy blue whale calls from noise loggers deployed around Scott Reef (2006 to 2009) for the Woodside Browse project showed that 78% of the calls were from lone whales, 18% were from two whales and 4% were from three or more whales (McCauley 2011; Woodside 2014). A maximum of five individuals were recorded calling concurrently.

Conservation advice from the DoEE (2015a) for the blue whale states that biologically important areas should be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area. Based on the known distribution, preferred feeding habitats and migration pathways of pygmy blue whales, and observations from the noise monitoring program (**Section 5.4.7**), it is considered possible that individuals may be encountered in low numbers during the project. However, there are no BIAs for pygmy blue whales within the project area. Individuals are most likely to be present in the Barossa offshore development area and northern end of the gas export pipeline where it is located in deep offshore waters. Pygmy blue whales are unlikely to aggregate within the Barossa offshore development area for feeding given there are no significant upwellings or benthic habitat features in the area.

Bryde's whale

Bryde's whales (*Balaenoptera edeni*; migratory) are considered the least migratory of the whale species found in Australian waters as they do not appear to undertake long distance low-high latitude migrations. However, some populations have been observed to move toward the equator in the winter and away from it in the summer (Best 1977; Valdivia et al. 1981; Wiseman et al. 2011; cited in JASCO 2016a). In general, the species is restricted to waters between 40° south and 40° north year round (Bannister et al. 1996; DoEE 2017e). The species occurs in both oceanic and nearshore waters, following zones of upwelling where they feed on shrimp-like crustaceans (Bannister et al. 1996). Little is known about the population abundance of Bryde's whale and there are no estimates of the exact breeding and calving grounds (DoEE 2017e; Chevron 2011a).

A few individuals of Bryde's whale were detected in the Barossa marine studies program from January to early October. JASCO (2015) commented that the presence of the species would be expected based on the findings of a number of studies, which noted the occurrence of the species in the Timor Sea and surrounding waters. Therefore, it is possible that Bryde's whale may transit through the project area and area of influence but they are not expected to be present in significant numbers.

Omura's whales

Omura's whales (*Balaenoptera omurai*) were only described as a new species basal to the Bryde's whale group in 2003 (Wada et al. 2003) and remain poorly understood in terms of their spatio-temporal distribution. While distantly related to Bryde's whales (Cerchio et al. 2015), the two species share some life history traits such as remaining in tropical waters, as opposed to undertaking large-scale seasonal migrations characteristic of other baleen whales (JASCO 2016a). Omura's whales are not listed under the EPBC Act but are listed on the IUCN Red List as Data Deficient (IUCN 2017).

A scientific study undertaken by Cerchio et al. (2015), which assessed the ecology and behaviour of Omura's whales off the north-west Madagascar, has provided some valuable insight into the species. Omura's whales, when present in the Madagascar region (October to November), appeared to be distributed solely on the shallow continental shelf habitat, within approximately 10 km–15 km of the shelf break and predominantly in water depths of 10 m–25 m (however, they were observed in depths of up to 202 m) (Cerchio et al. 2015). Cerchio et al. (2015) noted that other studies have suggested that the species also inhabits deeper waters, with observations made only off the Cocos Islands and eastern Indian Ocean from research whaling data. Feeding in the shelf habitat was frequently observed and was thought to be related to patchy food resources that were most likely zooplankton (Cerchio et al. 2015).

Omura's whales were recorded within the Barossa offshore development area throughout April to September inclusive, with a peak in June and July (JASCO 2016a). Based on the recordings, the whales appeared to pass through the region in a south-west to north-east direction. A higher number of recordings were observed in the vicinity of Evans Shoal and south of the Barossa offshore development area during the autumn and winter months. Therefore, it is likely that Omura's whales may transit the Barossa offshore development area, northern end of the gas export pipeline corridor and area of influence.

Sei whale

Sei whales (*Balaenoptera borealis*; vulnerable) have a wide distribution and display well-defined migratory movements between polar, temperate and tropical waters (DoEE 2017e). While the species has been observed infrequently in Australian waters, they are known to move through Australian waters to feeding areas in the Antarctic/sub-Antarctic (DoEE 2017e). Sei whales breed in tropical and sub-tropical waters, however, there are no known mating or calving areas in Australian waters.

Based on their known distribution and movements, it is considered possible that individual sei whales may be encountered in low numbers during the project; most likely in the Barossa offshore development area and northern end of the gas export pipeline corridor where it is located in deep offshore waters.

Fin whale

Fin whales (*Balaenoptera physalus*; vulnerable) have a wide distribution in offshore waters and, like the sei whale, display well defined migratory movements between polar, temperate and tropical waters (DoEE 2017e). These migratory movements appear to be effectively north–south with little longitudinal dispersion as the whales move between the higher latitude summer feeding grounds, such as the Australian Antarctic waters and Bonney upwelling area off Victoria, to lower latitude winter breeding grounds (DoEE 2017e).

Considering the species known distribution and movements, it is considered possible that individual fin whales may pass through the project area in low numbers; most likely in the Barossa offshore development area and northern end of the gas export pipeline corridor where it is located in deep offshore waters.

Humpback whales

Humpback whales (*Megaptera novaeangliae*; vulnerable) have a wide distribution, with recordings throughout Australian Antarctic waters and offshore from all Australian states (Bannister et al. 1996). Humpback whales breed and calve in the NWMR between Broome and the northern end of Camden Sound in the months of June to September each year (DoE 2015b; DoEE 2017e). A biologically important breeding and calving area for humpback whales is recognised in nearshore waters adjacent to the northern half of the Dampier Peninsula and encompasses Camden Sound (**Figure 5-15**; DoEE 2017c).

Humpback whales migrate between summer feeding grounds in Antarctica and winter breeding and calving grounds in the sub-tropical and tropical inshore waters of north-west Australia (Jenner et al. 2001). A biologically important migration area for humpback whales is recognised in nearshore waters (< 100 km) along the coast from west of Esperance to 100 km north of Broome (DoEE 2017c). The northbound migration peaks between late July and early August, and the southbound migration peaks between late August and early September (Jenner et al. 2001). Relatively few humpback whales have been known to travel north of Camden Sound (Jenner et al. 2001), which is located more than approximately 820 km south-west of the Barossa offshore development area. In addition, no humpback whales were recorded during the 12 months of noise monitoring undertaken as part of the Barossa marine studies program (JASCO 2016a). Therefore, the species is considered unlikely to transit through the project area but may occur within the area of influence.

Antarctic minke whale

Antarctic minke whales (*Balaenoptera bonaerensis*; migratory) occur worldwide and have been recorded off all Australian states, primarily in offshore waters (DoEE 2017e). The species has not been recorded in the NT (DoEE 2017e). Antarctic minke whales undertake extensive breeding migrations between Antarctic feeding grounds and temperate/tropical waters during the Australian winter, although the exact location of their breeding grounds is unknown (Bannister et al. 1996). It is suggested that Antarctic minke whales migrate up the WA coast as far north as 20°S (Bannister et al. 1996). Based on the extent of the species range, it is considered unlikely that they will be present in the area of influence. However, if they do occur it is expected that only a few individuals may transit through the area.

Killer whale

The killer whale (*Orcinus orca*; migratory) is found in all the world's oceans and has been recorded in waters of all Australian states/territories (DoEE 2017e). While killer whales are known to undertake seasonal migrations, and follow regular migratory routes, little is known about these movements (DoEE 2017e). No areas of significance and no determined migration routes have been identified for this species within the project area or area of influence. It is possible that killer whales may transit through the area of influence but they are not expected to be present in significant numbers.

Sperm whale

Sperm whales (*Physeter microcephalus*; migratory) are found worldwide in deep waters (> 200 m) off continental shelves and shelf edges (Bannister et al. 1996). Sperm whale sightings have been recorded from all Australian states, however, key localities for sperm whales are between Cape Leeuwin and Esperance in WA (Bannister et al. 1996), which is more than 1,500 km from the area of influence. The area of influence is unlikely to represent important habitat for this species, and it is therefore expected that only very low numbers of individuals may be present.

Dugong

Dugongs (*Dugong dugon*; migratory) occur in tropical and sub-tropical coastal and island waters broadly coincident with the distribution of seagrasses (DoEE 2017e; Groom et al. 2017). Seagrass habitats typically occur in shallow intertidal zone areas to water depths of around 25 m. To a lesser extent seagrasses have been recorded at depths up to 50-60 m, however seagrass meadows at these depths are likely to be inaccessible given the limitations of dugongs diving range beyond approximately 35 m (DoEE 2017e). Dugong feeding aggregations tend to occur in large seagrass meadows within wide shallow protected bays, shallow mangrove channels and in the lee of large inshore islands.

An aerial survey of northern Australia coastal waters was undertaken in 2015 to assess the distribution and abundance of dugongs in NT coastal waters. While survey effort was affected by poor visibility (due to high turbidity), 151 dugong groups consisting of 229 individuals were identified (Groom et al. 2017). Dugong density in the waters surrounding the Tiwi Islands were reported as 0.11/km^2 with small group sizes (observed to be on average 1.28–1.36 individuals). Based on the survey results, the dugong population in NT coastal waters was estimated at 8,176 individuals (Groom et al. 2017).

The north coast of the Tiwi Islands (located approximately 100 km south and approximately 6 km east of the Barossa offshore development area and gas export pipeline corridor closest point, respectively) is recognised as a key site for the conservation of dugongs (Parks and Wildlife Service NT (PWSNT) 2003). A well-known major dugong aggregation of approximately 4,400 individuals occurs in waters seaward (within approximately 50 km) of the Tiwi Islands and ranks in the top eight of dugong populations in Australia (PWSNT 2003). **Figure 5-16** shows significant sites for dugongs and seagrass around the Tiwi Islands.

Dugongs have been tracked moving long distances of up to 300 km between the Australia mainland and the Tiwi Islands (Whiting 2008). Satellite-tracking data from dugongs tagged as part of the INPEX Ichthys Project baseline surveys observed that dugongs around the Vernon Islands, south of Melville Island, spent time in Darwin Harbour and around the Tiwi Islands (INPEX 2010). The number of dugongs observed in Darwin Harbour is relatively low and is thought to reflect the scarcity of seagrass habitat (Whiting 2008). Routine dugong monitoring surveys undertaken for the INPEX Ichthys project recorded a number of dugongs at various locations along the NT coastline, including within Darwin Harbour, to the south of Melville Island, within Shoal Bay to the north of Darwin Harbour (highest frequency of sightings) and within the vicinity of Grose Island, Dum In Mirrie Island and Indian Island (south-west of Darwin Harbour) (Cardno 2013).

Dugongs in the NT coastal waters have been observed foraging on intertidal rocky reef flats supporting sponges and algae as seagrass habitat is thought to be rare in the NMR bioregion (Whiting 2008, cited in INPEX 2010). However, seagrass communities are known along the north coast of the Tiwi Islands (Woinarski et al. 2003; McKenzie 2008, cited in JacobsSKM 2014) and, to a smaller extent, in Darwin Harbour (JacobsSKM 2014).

Given the habitat preferences of dugongs and the known distribution of seagrass around the Tiwi Islands, the species may occur in the shallow or nearshore waters of the area of influence.

Dolphins

Dolphins have been reported as being abundant in some offshore areas of the Timor Sea and are regularly seen by commercial fishers near Evans Shoal (CEE 2002). Migratory species known to occur in the region include the spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*), Indo-pacific humpback dolphin (*Sousa chinensis*), and the Australian snubfin dolphin (*Orcaella heinsohni* (formally known known as the Irrawaddy dolphin). No breeding areas are known to occur within the project area.

Spotted bottlenose dolphin

The spotted bottlenose dolphin (Arafura/Timor Sea populations) (*Tursiops aduncus*), listed as migratory under the EPBC Act, favours deeper, more open coastal waters, primarily in continental shelf waters (< 200 m deep), including coastal areas around oceanic islands (DSEWPaC 2012a). Biologically important foraging (provisioning of young), feeding and breeding area has been identified in Darwin Harbour, in which the species is mostly present during the dry season (April–November) (DSEWPaC 2012a). Breeding and foraging behaviour has not been seen beyond the mouth of the harbour (C. Palmer, pers. comm., 2011, cited in DSEWPaC 2012a).

A study undertaken by Brooks et al. (2017) monitored abundance, distribution and movement patterns of three coastal dolphin species, including the bottlenose dolphin (*Tursiops* sp.), in Darwin Harbor and two neighboring sites (Shoal Bay to the north and Bynoe Harbour to the south) over three and a half years (October 2011-April 2015). The study observed that bottlenose dolphins appeared to move relatively freely between all sites and that population numbers were relatively stable and comparable to other local populations in Australia. Furthermore, the study reported that an unusually large increase in the October 2012 estimate suggests immigration occurs and that there is a degree of connectivity between the Darwin area population and dolphins outside the sample area.

Indo-pacific humpback dolphin

The Indo-pacific humpback dolphin (*Sousa sahulensis*), which is listed as migratory under the EPBC Act, is known to occur along the northern Australian coastline from Exmouth in WA to the Queensland/New South Wales (NSW) border region (DoEE 2017e). The species' preferred habitat is shallow (generally < 20 m in depth) coastal, estuarine and riverine (occasional) waters. However, individuals have been observed in shallow waters up to 55 km offshore. The species breeds throughout the year, with calving peaks reported to occur in the spring and summer months across most of their range (DoEE 2017e).

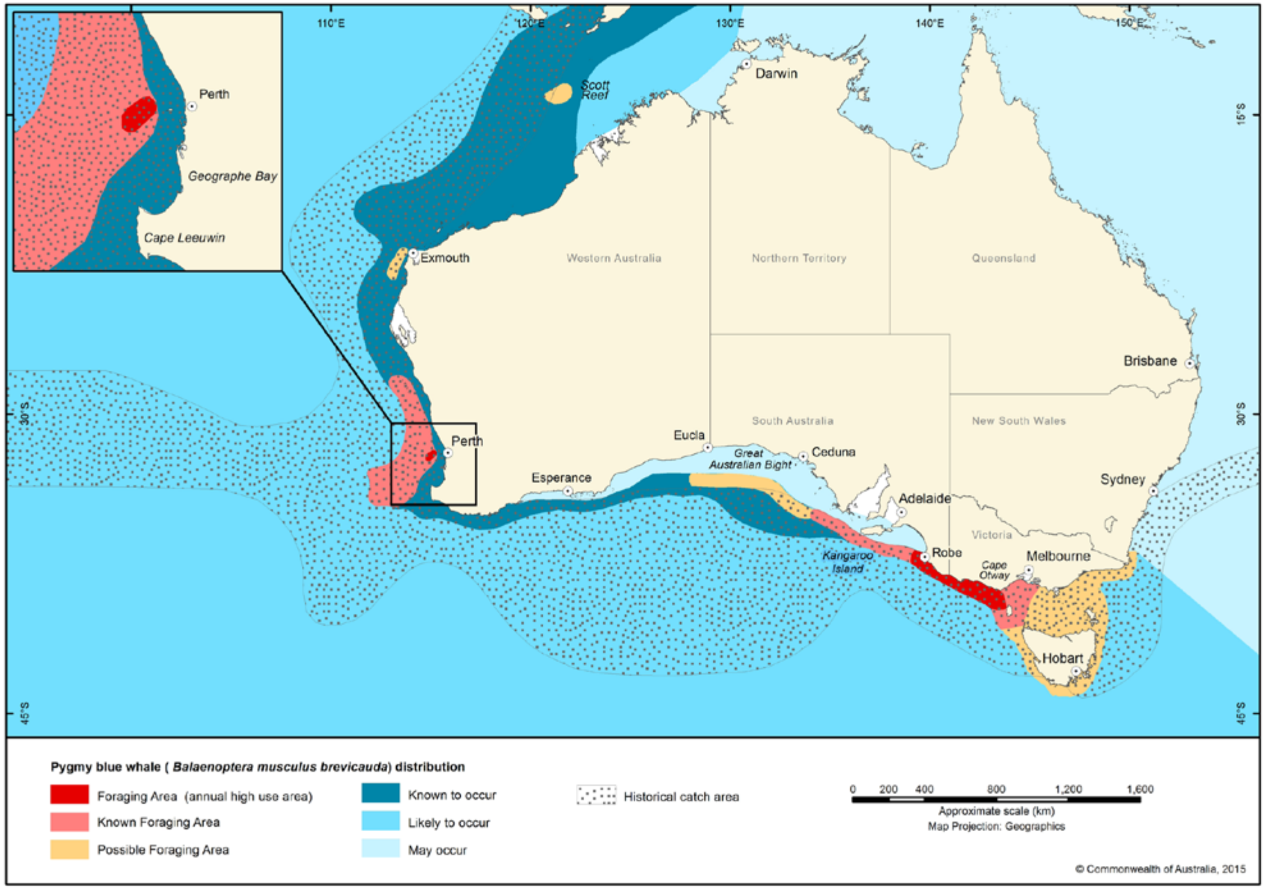
The study undertaken by Brooks et al. (2017), as outlined above, observed that the species was distributed over the entire area surveyed, with sightings in the majority of the available habitats. The study also noted the population was stable and that immigration and emigration of individuals occurred between sites and outside areas (Brooks et al. 2017). It is thought that the movement and ranging patterns of coastal dolphins, such as the Indo-pacific humpback dolphin, in monsoonal northern Australia reflect seasonal influences and spatial and temporal variation in the abundance of prey species (Brooks et al. 2017).

The Indo-pacific humpback dolphin is relevant to the project only in terms of the area of influence as a large unplanned release in the vicinity of the southern end of the gas export pipeline has the potential to overlap a small portion of the biologically important breeding, calving and foraging area in Darwin Harbour and surrounding waters (**Figure 5-15**). Numbers generally tend to be greater within the biologically important area in Darwin Harbour between November and March (DSEWPaC 2012d).

Australian snubfin dolphin

The Australian snubfin dolphin (*Orcaella heinsohni*; formerly known as the Irrawaddy dolphin) shares similar habitat preferences with the Indo-Pacific humpback dolphin, occurring in shallow coastal and estuarine waters (typically less than 20 m deep) (DoEE 2017e). The species has been recorded out to 23 km offshore. In Australia, the species distribution covers the coastal waters of Queensland, NT and north-western Australia. The population in Australian waters is thought to be continuous with the Papua New Guinea species, but separate from populations in Asia. Brooks et al. (2017) noted that the species showed clear evidence of connectivity between the local population of dolphins in Darwin Harbour and those in the surrounding area. While the breeding season in the NT is not defined, the species is understood to mate from April to June at 0°–1° south (Ross 2006, cited in DoEE 2017e). Calves are generally born in August/September following a 14 month pregnancy (DoEE 2017e). Given the preferred coastal range of the species, it is likely that the project may only influence the Australian snubfin dolphin in the event of a major unplanned spill event.

The oceanic species and populations of dolphins that may occur within area of influence are nomadic feeders, in contrast to coastal populations that tend to have defined territories. Therefore, if present, they are likely to transit through the area as opposed to being resident in a defined area for significant periods of time.

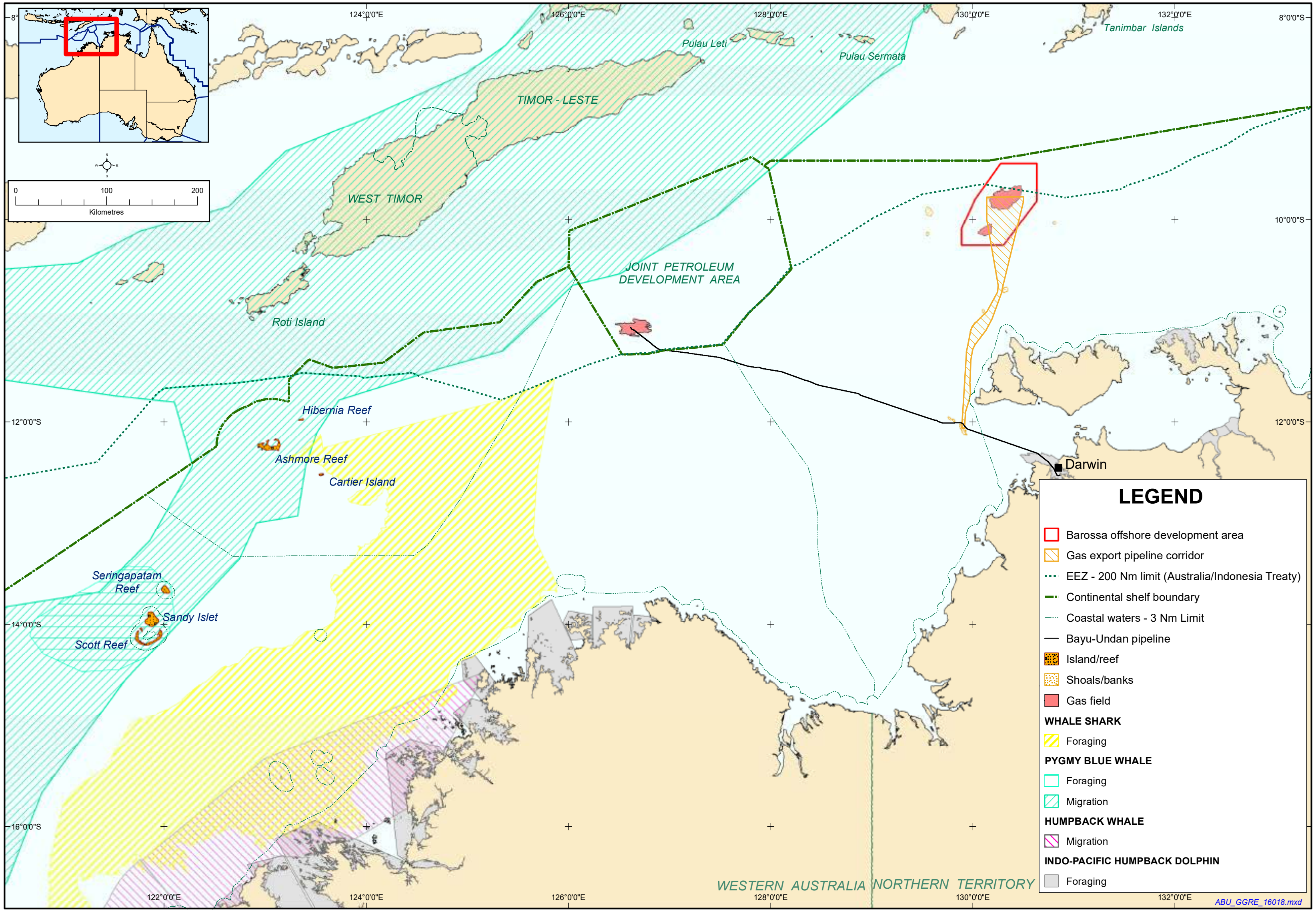


Foraging Area (Annual high use area)	Blue whales are regularly observed feeding on a seasonal basis
Known Foraging Area	Known foraging occurs in these areas but is highly variable both between and within seasons
Possible Foraging Area	Evidence for feeding is based on limited direct observations or through indirect evidence, such as occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Blue whales travel through on a seasonal basis, possibly as part of their migratory route

Known to occur	Blue whales are known to occur based on direct observations, satellite tagged whales or based on acoustic detections
Likely to occur	Blue whales are likely to occur based on occasional observations in the area and nearby areas
May occur	Evidence for the presence of blue whales through strandings or rare observations
Historical catch area	Blue whales were caught during the whaling period based on whaling data

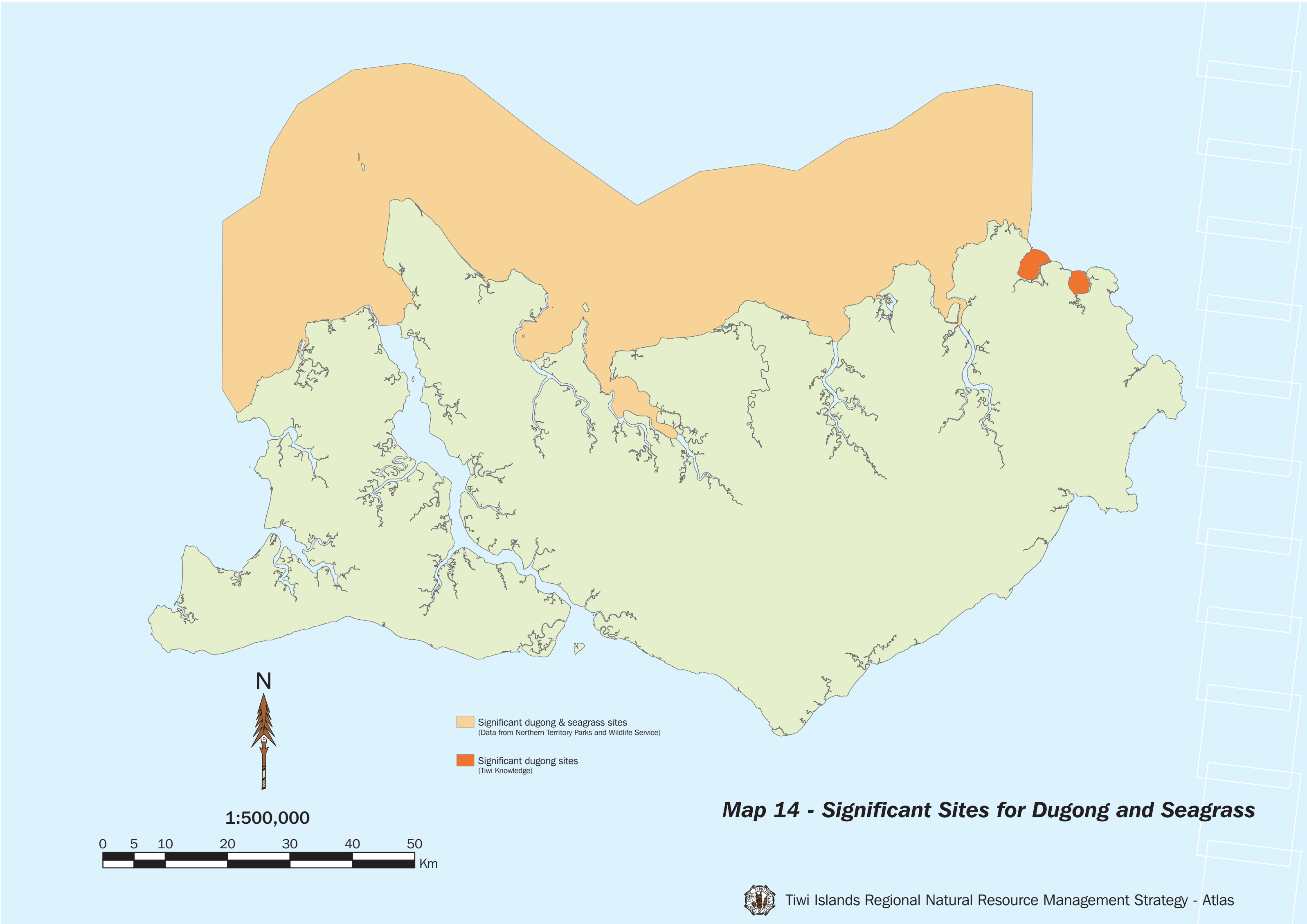
(Source: DoEE 2015a)

Figure 5-14: Pygmy blue whale distribution around Australia



(Source: National Conservation Values Atlas; DoEE 2017c)

Figure 5-15: Biologically important areas for marine mammals and whale sharks



(source: Tiwi Land Council 2017)

Figure 5-16: Significant sites for dugongs and seagrass around the Tiwi Islands

5.6.3 Marine reptiles

5.6.3.1 Regional overview

A range of marine reptiles were identified as potentially occurring or having habitat in the project area and surrounding waters of the Timor Sea. Of these, marine turtles, sea snakes and salt water crocodiles are mostly likely to occur within the project area or the area of influence and are discussed further below.

5.6.3.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Marine turtles

A search of the EPBC Act Protected Matters database identified six threatened species of marine turtle that may occur in the project area and area of influence (**Section 5.5.1**). The biologically important areas for turtle species in the NMR are shown in **Figure 5-17** (DoEE 2017c). The internesting habitat critical to the survival of marine turtles as relevant to the project is shown in **Figure 5-18** (DoEE 2017a).

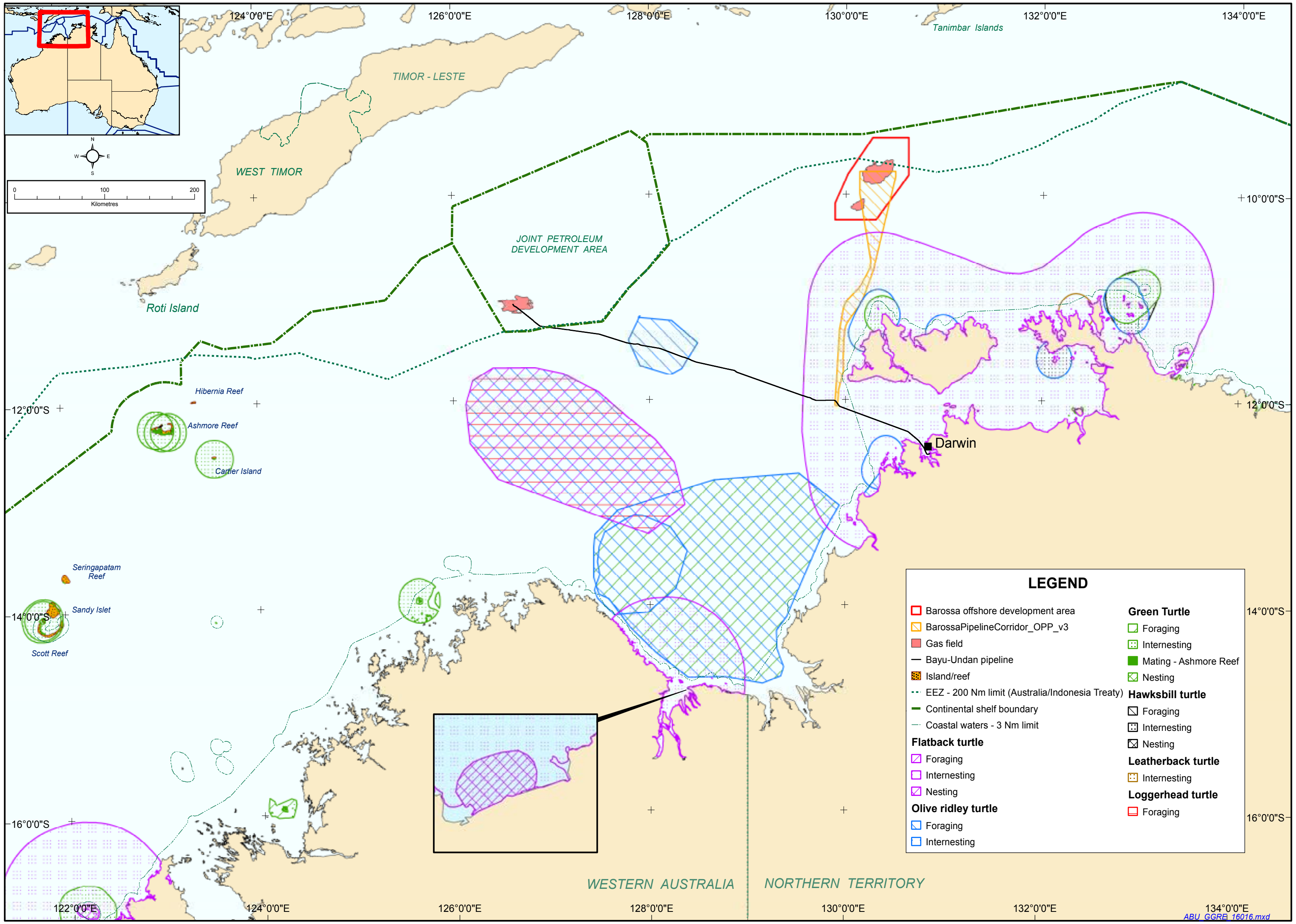
Turtles are oceanic species except at nesting time when they come ashore (DoEE 2017a). The nesting season is species-dependent and varies along the NT coastline in response to the different seasonal conditions. Female turtles also exhibit an internesting phase where they spend 2–3 months in the vicinity of the nesting island (Guinea 2013). During this period, the turtles typically remain in shallow waters close to the nesting beach or rookery while they produce the next clutch of eggs (DoEE 2017a). Turtles do not feed during the internesting period but will rest on the seabed (pers. comm. M. Guinea, CDU, 2015; Plotkin et al. 1994, cited in Whiting et al. 2005). The incubation time between turtle nesting and emergence of hatchlings varies between species, but is generally about 2 months (DoEE 2017a).

Key aggregation/nesting/feeding areas include:

- The NT coastal region is considered significant for turtle breeding, nesting and feeding aggregations. In particular, the northern coast of Melville Island is a nationally and internationally important nesting area (Chatto and Baker 2008).
- The sandy beaches on the Tiwi Islands, specifically the west coast of Bathurst Island and the north coast of Melville Island, are important, with nesting dominated by flatback turtles (*Natator depressus*; vulnerable) and olive ridley turtles (*Lepidochelys olivacea*; endangered) (Chatto and Baker 2008). Green turtles (*Chelonia mydas*; vulnerable) and hawksbill turtles (*Eretmochelys imbricata*; vulnerable) also nest on the Tiwi Islands, although in smaller numbers.
- Flatback turtles are the most widespread nesting species in the NMR. Flatback turtles nesting within the NT are all from the Arafura Sea breeding area (genetic stock) (DoEE 2017a). The west coast of Bathurst Island is an important nesting area for flatback turtles (pers. comm. M. Guinea, CDU, 2015). Nesting occurs year round with a peak during June and August (DoEE 2017a, Pendoley 2017).
- Olive ridley turtles nest in nationally significant numbers along the northern coast of the Tiwi Islands (Melville Island in particular), and in low density on the beaches of the west and south-west coast of the Tiwi Islands (Bathurst Island) (Chatto and Baker 2008). Nesting of the NT genetic stock occurs between February and September, with a peak between April and June (DoEE 2017a, Pendoley 2017).
- Green turtles have not been recorded nesting in the Bonaparte or Van Diemen Gulf bioregions, with the exception of two significant nesting sites; Black/Smith Point and Lawson Island, which are east of the Tiwi Islands and in the vicinity of Cobourg Peninsula (Chatto and Baker 2008). Some nesting has been recorded on the west coast of Bathurst Island (pers. comm. M. Guinea, CDU, 2015). The nesting period varies along the NT coast. However, the Cobourg Peninsula genetic stock of green turtles, which is the closest to the Tiwi Islands, nests between October and April with the peak nesting period occurring between December and January (DoEE 2017a).
- The NT sub-population of the hawksbill turtle is one of the few very large nesting populations remaining in the world, breeding year-round (Chatto and Baker 2008). However, there are no recorded nesting sites along the western NT coast.
- Biologically important internesting areas for the flatback turtle encompass a large area of nearshore waters between approximately Daly River to the west and Goulbourn Island to the east and surround the entire Tiwi Island coastline (DoEE 2017c; **Figure 5-17**). The National Conservation Values Atlas presents an 80 km internesting buffer around the Tiwi Islands (DoEE 2017a).

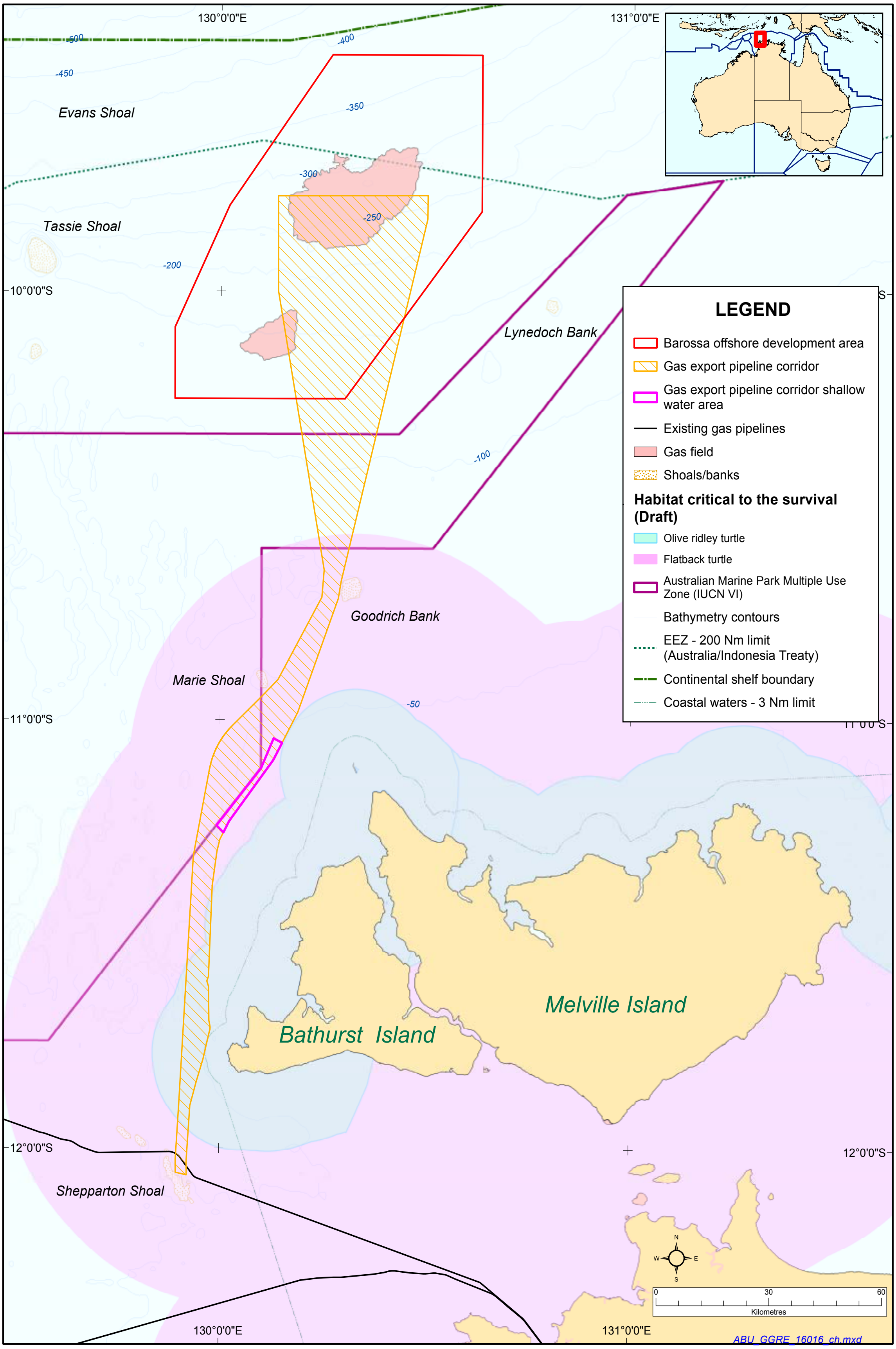
[1] It is expected that the National Conservation Values Atlas will be updated in due course to reflect the more recently published recovery plan.

- Internesting habitat critical to the survival of flatback turtles (Arafura stock) encompasses a large area of nearshore waters between approximately Daly River to the west and Endyalgout Island/west coast of Cobourg Peninsula to the east and surround the entire Tiwi Island coastline (DoEE 2017a, d; **Figure 5-18**). The Recovery Plan for Marine Turtles in Australia defines the internesting buffer around the Tiwi Islands as 60 km (DoEE 2017a). However, it has been demonstrated via an extensive study tracking 47 internesting flatback turtles from five different mainland and island rookeries over 1,289 tracking days that flatback females remained in water depths of <44 m, favouring a mean depth of <10 m (Whittock et al. 2016). Whittock et al. (2016) defined suitable internesting habitat as water 0 m–16 m deep and within 5 km–10 km of the coastline, and unsuitable internesting habitat was defined as water >25 m deep and >27 km from the coastline. There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the internesting period (Pendoley 2017; **Appendix Q**). The seabed characteristics off Cape Fourcroy at the south-western tip of Bathurst Island (i.e. narrow continental shelf, steep seabed slope and relatively high current speeds) are not typical of the internesting habitat used by flatback turtles and consequently they are unlikely to inter-nest in the pipeline corridor waters in this area (Pendoley 2017). Further to the north where the continental shelf is wider and slopes more gently offshore, the 10 m deep internesting grounds are located approximately 10 km–20 km inshore of the pipeline corridor. Internesting of the Arafura genetic stock occurs year-round with a peak during June to September (DoEE 2017a, Pendoley 2017). Based on the outcomes of these studies, most of the nesting females in the area are not expected to internest within the pipeline corridor, however, it is possible some individuals will use waters extending into the corridor (Pendoley 2017).
- Biologically important internesting areas for the olive ridley turtle and green turtle are known to occur along two areas on the north coast of the Tiwi Islands and in the vicinity of Cobourg Peninsula (**Figure 5-17**). The National Conservation Values Atlas defines an internesting buffer of 20 km from the Tiwi Islands for these turtle species (DoEE 2017c). Internesting of the NT genetic stock of olive ridley turtles occurs year round with a peak between April and August (DoEE 2017a, Pendoley 2017). Internesting of the Cobourg Peninsula genetic stock of green turtles occurs between October and April (DoEE 2017a).
- Internesting habitat critical to the survival of olive ridley turtles (NT stock) encompasses nearshore waters along the north, west and east coasts of the Tiwi Islands (DoEE 2017a, d; **Figure 5-18**). The Recovery Plan for Marine Turtles in Australia defines the internesting buffer around the Tiwi Islands as 20 km (DoEE 2017a). Tagging studies on internesting olive ridley turtles in the region recorded that the individuals remained close to shore (water depths typically less than 30 m deep) and within 50 km of the nesting beach during the internesting interval (Hamel et al. 2008).
- Marine turtles forage predominantly on shallow benthic habitats, either nearshore or at offshore reefs (generally in waters up to approximately 50 m deep and including coral and rocky reefs), containing seagrass and/or algae, and inshore seagrass beds. Benthic habitats at shoals and banks near the project area (described in **Section 5.5.2**), which are present at water depths ranging from 10 m–30 m (at the top of the shoal/bank), represent important foraging grounds for marine turtles.
- The waters of the Joseph Bonaparte Gulf represent a biologically important foraging area for green and olive ridley turtles (DoEE 2017c). Important foraging areas for the olive ridley turtle extend into more open offshore waters, mainly to the north-west in the NWMR (DoEE 2017c). Olive ridley turtles are known to be deep divers and have been recorded in water depths up to 200 m (pers. comm. S. Whiting, DPaW, 2016).
- The biologically important foraging area for flatback turtles, olive ridley turtles and loggerhead turtles (*Caretta caretta*; endangered) in the NWMR offshore from Cape Londonderry (**Figure 5-17**) is known to support a high density of turtles and is considered to extend further to the west than currently mapped on the National Conservation Values Atlas (pers. comm. S. Whiting, DPaW, 2016). The benthic communities in these areas provide high quality feeding habitats (DoEE 2017c).
- Flatback and olive ridley turtles are primarily carnivorous and feed predominantly on soft-bodied invertebrates (DoEE 2017a). Olive ridley turtles have been known to feed in water depths between 15 m and 200 m.
- Green turtles are primarily herbivorous and forage on shallow benthic habitats (in depths < 120 m) containing seagrass and/or algae, including coral and rocky reefs, and inshore seagrass beds (DoEE 2017a).
- Loggerhead turtles have been recorded occasionally offshore from the NT but nesting has not been observed for this species on the coastline (Chatto and Baker 2008; DoEE 2017a). The species is carnivorous and mainly feeds on benthic invertebrates in habitats ranging from nearshore to 55 m in depth (DoEE 2017a).
- Leatherback turtles (*Dermochelys coriacea*; endangered) feed on plankton and jellyfish in oceanic waters around Australia (DoEE 2017a). Small numbers of leatherback turtles nest on Cobourg Peninsula (DoEE 2017a).
- It has been suggested that Evans Shoal may be an important area for turtles (pers. comm. M. Guinea, CDU, 2015).



(Source: National Conservation Values Atlas; DoEE 2017c – as accessed February 2017, DoEE 2017d – as accessed October 2017)

Figure 5-17: Biologically important areas for marine turtles



(Source: National Conservation Values Atlas; DoEE 2017d – as accessed October 2017)

Figure 5-18: Internesting habitat critical to the survival of marine turtles

Key migratory pathways:

- Most species of turtles are known to migrate large distances between foraging and nesting areas. For example, olive ridley turtles and green turtles are known to migrate up to 1,130 km and 2,600 km respectively between their nesting and foraging grounds (Whiting et al. 2005; DSEWPaC 2012b).
- Flatback turtles that nest within the Pilbara region migrate to their foraging grounds in the Kimberley region along the continental shelf at the end of the nesting season.
- Surveys of green turtle movements after nesting in the Kimberley region show many turtles traveling north to the Tiwi Islands south coast (RPS 2009, cited in URS 2010) and Gulf of Carpentaria in April/May (pers. comm. M. Guinea, CDU, 2015).
- Hawksbill turtles migrate along the Dampier Archipelago and between Scott Reef and the Joseph Bonaparte Gulf.

The Barossa offshore development area does not contain any emergent land or shallow features that may be of importance to nesting or feeding turtles and, therefore, they are unlikely to be present in the area in significant numbers. However, low numbers are likely to transit the area as they move from nesting beaches and offshore areas (pers. comm. M. Guinea, CDU, 2015). For example, flatback turtle hatchlings have been observed in offshore areas in the vicinity of Evans Shoal while hawksbill turtles were discovered aboard an illegal fishing vessel operating at Evans Shoal (pers. comm. M. Guinea, CDU, 2015). A small number of individual turtles, including flatback, olive ridley and hawksbill (juvenile) turtles, were also opportunistically observed during the Barossa marine studies program in both open waters and in close proximity to shoals/banks and Bathurst Island. Increased numbers of marine turtles may transit the gas export pipeline given its closer proximity to emergent land or shallow features and there are known biologically important internesting areas surrounding the Tiwi Islands.

Sea snakes

All sea snakes in Australia are listed as protected species under the EPBC Act. A search of the EPBC Act Protected Matters database identified 24 species of sea snake that may occur in, or have potential habitat in the area of influence, with 18 of these species also potentially occurring in the project area. Nineteen species of sea snakes are known to occur in the NMR, with a further nine species potentially occurring (DSEWPaC 2012c).

Key aggregation/feeding areas:

- Sea snakes are typically distributed in shallow inshore regions and islands, which provide suitable seabed habitat and clear waters. However, they are also found at nearby islands and further offshore at atolls, including the shoals/banks in the Timor Sea (Guinea 2013).
- The majority of sea snakes are observed in water depths ranging between 10 m and 50 m deep (RPS 2010) and generally have shallow, benthic feeding patterns. Some species are known to dive deeper than this, but non-pelagic species seldom, if ever, dive deeper than 100 m (Heatwole and Seymour 1975). Very few species are known to inhabit deep pelagic environments, such as those occurring in the Barossa offshore development area, as they are air-breathing (Guinea 2006).
- Distribution and movements of sea snakes are largely species-dependent with some species, such as the pelagic yellow-bellied sea snake, known to travel large distances, while others, such as the olive sea snake, are usually resident in a particular area.
- Sea snake species residing on reefs do not actively disperse or migrate between reefs. Sea snakes are found to be present year-round at most reefs on the Sahul Shelf (Guinea and Whiting 2005).
- For those sea snake species that do migrate between reefs, within their broader home range, migration is thought to be influenced by ocean currents. However, there have been no studies undertaken to date on the migrations of open water sea snake species to determine their home ranges (Guinea 2013).
- Reef dwelling sea snakes appear to have very small home ranges (Guinea 2013).
- Research trawls indicate that the sea snakes move to the southern shallow regions of the Gulf of Carpentaria in the summer months and into deeper water at other times of the year (Redfield et al. 1978, cited in DSEWPaC 2012b).
- Sea snakes are known to breed in shallow embayments along the NT coastline around December-February, with the exception of the spine-bellied sea snake which breeds during June–August (DSEWPaC 2012b).

There have been few surveys undertaken on sea snakes within the NMR, with the majority of the knowledge originating from trawling by-catch. A study by Fry et al. (2001) found that there were four common sea snake species caught as by-catch by the Northern Prawn Fishery; olive-headed sea snake, elegant sea snake, spotted sea snake and spine-bellied sea snake. In addition, a researcher aboard a trawling vessel reported a healthy population of the yellow-bellied sea snakes that was not recorded in the trawl by-catch (Limpus 2001). A study undertaken at Tassie Shoal and five surrounding shoals identified two species of sea snake at the surface and foraging on the seabed: the olive sea snake and the turtle-headed sea snake (CEE 2002). Recent surveys undertaken for the Barossa marine studies program observed several sea snake individuals at Evans Shoal, Tassie Shoal, Lynedoch Bank and a seamount to the west of the Barossa offshore development area. A number of opportunistic sightings (species unknown) were also made in open offshore waters in the Timor Sea. The individuals that could be identified were the olive sea snake and turtle-headed sea snake (Heywood et al. 2015; Jacobs 2016c). A study undertaken at Tassie Shoal and five surrounding shoals identified two species of sea snake at the surface and foraging on the seabed: the olive sea snake and the turtle headed sea snake (CEE 2002).

Two threatened species that may occur in the area of influence are the short-nosed sea snake (*Aipysurus apraefrontalis*; critically endangered) and the leaf-scaled sea snake (*Aipysurus foliosquama*; critically endangered). Neither of these species were identified in the Barossa offshore development area or gas export pipeline corridor search areas.

The short-nosed sea snake and the leaf-scaled sea snake are commonly encountered at Ashmore and Hibernia Reefs, which are located approximately 750 km to the south-west of the Barossa offshore development area. The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m (DSEWPaC 2010a). The species were relatively common in reef surveys undertaken from 1994-1998 but have since become scarce. The species have not been recorded at Ashmore or Hibernia Reefs since the late 1990s and 2001 for the short-nosed sea snake and the leaf-scaled sea snake respectively, despite a fivefold increase in survey effort (DoEE 2017e). The decline of sea snakes at Ashmore Reef is likely multi-faceted and has been attributed to ecosystem degradation due to major coral bleaching events in the 1990s associated with warm ocean water events.

Based on the known distribution, habitat preference and sightings during the Barossa marine studies program, sea snakes are considered likely to transit the project area and area of influence.

Salt-water crocodile

The salt-water crocodile (*Crocodylus porosus*) is a listed migratory species identified as occurring in the project area and the area of influence. Protection of the salt-water crocodile under the EPBC Act is applied to regulate commercial hunting, particularly for the trade in crocodile skins, which has historically resulted in population declines (DoEE 2017e). However, the current export-orientated crocodile industry is regulated and wild populations of the species are not considered threatened (PWSNT 2005). The saltwater crocodile occurs within the nearshore marine and estuarine waters of the Kimberley coast (DoEE 2017e). In the NT most breeding sites are found on river banks or floating rafts of vegetation (DoEE 2017e). While there are no biologically important areas within the project area, such as breeding sites or critical habitat, transient individuals may occur in the shallow near-coast waters in the southern extent of the gas export pipeline corridor.

5.6.4 Birds (seabirds and migratory shorebirds)

5.6.4.1 Regional overview

A number of avifauna species, including seabirds and migratory shorebirds, are known to transit and have habitat within the Timor Sea region, as they range over large geographical areas. The EPBC Protected Matters search identified 13 migratory birds as potentially occurring within the project area, three of which were listed as threatened. An additional 45 listed migratory and/or marine bird species (including an additional seven threatened species) were identified to potentially occur or have habitat within the area of influence (**Appendix P**).

It is also understood that, based on current published information and advice from Dr Rohan Clarke (Monash University), an undescribed shearwater species ('Timor Sea Shearwater, Puffinis sp.) may potentially occur or have habitat within the project area and/or area of influence. The species was first detected in 2010 in the Timor Sea north-west of Darwin and West Papua (Menkhorst et al. 2017). Subsequent surveys have positively identified its occurrence, including near Adele Island and near Indonesia area (Rohan Clarke, pers. comm.). The majority of sightings have been in proximity to shoals/banks and shorelines as the species is likely to forage in inshore waters and aggregate as flocks that rest on the sea surface in these same waters (Rohan Clarke, pers. comm.). The species is more likely to breed in Indonesian waters based on observations to date, however this remains inconclusive at this time (Rohan Clarke, pers. comm.).

5.6.4.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

The EPBC Protected Matters search identified 13 migratory birds within the project area, three of which were listed as threatened. These species include the curlew sandpiper (*Calidris ferruginea*; critically endangered), eastern curlew (*Numenius madagascariensis*; critically endangered), red knot (*Calidris canutus*; endangered), streaked shearwater (*Calonectris leucomelas*), common noddy (*Anous stolidus*), greater frigatebird (*Fregata minor*), lesser frigatebird (*Fregata ariel*), fork-tailed swift (*Apus pacificus*) (gas export pipeline corridor only), osprey (*Pandion haliaetus*) (pipeline orridor only),crested tern (*Thalasseus bergii*) (pipeline corridor only), common sandpiper (*Actitis hypoleucos*) (pipeline corridor only), sharp-tailed sandpiper (*Calidris acuminata*) (pipeline corridor only) and pectoral sandpiper (*Calidris melanotos*) (pipeline corridor only). These species are discussed in detail below.

Through consultation with recognised technical experts, it is noted that the following 15 EPBC Protected species (all listed as migratory marine), in addition to the 13 listed above, are likely to also transit the project area on an annual basis; wedge-tailed shearwater (*Ardenna pacifica*), Bulwer's petrel (*Bulweria bulwerii*), Matsudaira's storm-petrel (*Hydrobates matsudairae*), Swinhoe's storm-petrel (*Hydrobates monorhis*), Wilson's storm-petrel (*Oceanites oceanicus*), red-tailed tropicbird (*Phaethon rubricauda*), white-winged black tern (*Chlidonias leucopterus*), bridled tern (*Onychoprion anaethetus*), common tern (*Sterna hirundo*), roseate tern (*Sterna dougallii*), lesser crested tern (*Thalasseus bengalensis*), little tern (*Sternula albifrons*), masked booby (*Sula dactylatra*), brown booby (*Sula leucogaster*) and red-footed booby (*Sula sula*).

No emergent land exists in the shoals or surrounding offshore areas in the vicinity of the Barossa offshore development area to support breeding populations of seabirds or migratory shorebirds. Most migrant birds are unlikely to land on the sea but will pass over the regional area as part of their transitory movements. Therefore, most seabird activity would be restricted to foraging, as opposed to seabird stopover and roosting points during annual migrations due to the absence of landing areas. It is also considered unlikely that migratory bird species would be observed near the sea surface of Tassie Shoal or surrounding shoals, given that there is no emergent land and the shoals are a considerable distance from Ashmore Reef (CEE 2002).

It is noted that seabirds are observed to spend some months at sea without returning to land, while shorebirds more typically do not interact with the sea surface and mostly overfly the area. Migratory wetland species also do not interact with the sea surface, therefore the only point of interaction is the potential for these species to land on infrastructure, especially during inclement weather, while flying between land masses.

Curlew sandpiper

The migratory wetland species of the curlew sandpiper has been recorded along the coasts of all Australian states and territories (DoEE 2017e). The species is also widespread inland, though their appearance is variable and often in small numbers (DoEE 2017e). In the NT, the curlew sandpiper occurs mostly around Darwin, north to Melville Island and Cobourg Peninsula, and east and south-east to Gove Peninsula, Groote Eylandt and Sir Edward Pellew Island (DoEE 2017e). The species most often inhabits intertidal mudflats in sheltered coastal areas species and forage in nearshore waters or mud at the edge of wetlands (DoEE 2017e). The curlew sandpiper does not breed in Australia as they migrate to northern breeding grounds in Siberia. While individuals can remain in northern Australian during the non-breeding season, the curlew sandpiper generally arrives in Australia around late August/early September and departs by mid-April (DoEE 2017e). Given the preferred habitat and feeding habits, the curlew sandpiper is very unlikely to land or interact with offshore waters during its migration over the Timor Sea.

Eastern curlew

The eastern curlew is found in coastal regions across all Australian states and territories and is rarely recorded inland (DoEE 2017e). The species undertakes annual migrations through the East Asian – Australasian Flyway to Russia and north-eastern China to breed and returns to Australia to feed (DoEE 2017e). The eastern curlew generally arrives in northern Australia through July to August and departs between late February and April (DoEE 2017e). In Australia, the species forages mostly on mudflats or sandflats, on saltflats and in sandmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DoEE 2017e). As with the curlew sandpiper, the eastern curlew is very unlikely to land or interact with offshore waters during its migration over the Timor Sea given the species preferred habitat and feeding habits.

Streaked shearwater

The streaked shearwater is a migratory seabird that breeds on islands in the north-west Pacific Ocean near Japan. The bird migrates from this region into the tropical west Pacific during the non-breeding season. In Australia, the streaked shearwater has been recorded from Broome to the Timor Sea, and from Barrow Island to the Houtman Abrolhos Islands. The species has been recorded regularly in northern Australia from October to March, with some records as early as August and as late as May (Marchant and Higgins 1990b, cited in DSEWPaC 2012d). The species is likely to occur in moderate numbers in the project area (pers. comm. R. Clarke, Monash University, 2016).

Common noddy

The common noddy is a migratory seabird species commonly encountered off the north-west and central WA coast and to a lesser extent off the NT coast. During the breeding season, the common noddy usually occurs on or near islands, on rocky islets or on shoals or cays of coral or sand (DoEE 2017e). Individuals generally remain close to the nest (within 50 km), foraging in the surrounding waters (DSEWPaC 2012d). There is only one known breeding location used by the common noddy in the NT, located on Higginson Islet, off Gove Peninsula (Chatto 2001), which is > 500 km from the project area.

Greater frigatebird

The greater frigatebird is widespread and breeds on numerous tropical islands offshore north-western Australia. Biologically important areas for breeding include Adele Island (2–300 pairs) and Ashmore Reef (small numbers). Breeding mostly occurs between March and November. The species occur in the open ocean, although breeding birds forage within 100 km–200 km of the colony during the early stages of the breeding season (DSEWPaC 2012b).

Lesser frigatebird

The lesser frigatebird is usually observed in tropical or warmer waters around the coast of northern WA, the NT, Queensland and northern NSW. The species remains further out to sea during the day and in the inshore waters during rough weather or in the late evening (Chatto 2001). The closest known breeding areas to the project area are on Ashmore Reef and Cartier Island (DSEWPaC 2012b). The lesser frigatebird breeds from March through to September and generally forages close to breeding colonies (DSEWPaC 2012b).

Fork-tailed swift

The fork-tailed swift has been recorded in all Australian states/territories as well as in the Timor Sea, both in open offshore waters and in the vicinity of offshore islands such as Ashmore Reef (Higgins 1999, cited in DoEE 2017e). The species generally arrives in Australia around October and departs by the end of April, is almost exclusively aerial, and does not breed in Australia (DoEE 2017e). The fork-tailed swift does not land or interact with offshore waters during its migration over the Timor Sea (pers. comm. R. Clarke, Monash University, 2016).

Osprey

The osprey is widely distributed throughout Australia and most commonly frequents coastal habitats (including offshore islands) (DoEE 2017e). The species has been observed in a variety of wetland habitats such as inshore waters, reefs and mangrove swamps, and forages in areas where there is an abundance of open fresh brackish or saline water (DoEE 2017e). The osprey breeds from April to February in Australia. The species does not occur in offshore waters, for example no individuals have been observed at Ashmore Reef – a significant site for a large number of migratory bird species – in over 20 surveys (pers. comm. R. Clarke, Monash University, 2016). Considering the osprey is generally resident in Australia, and based on its coastal habitat preference, the species is unlikely to be present in the project area as there is no suitable habitat.

Crested tern

The crested tern is widespread and numerous along the NT coastline, with 20 breeding colonies reported (DSEWPaC 2012a). The majority of these colonies are on small islands and support over 5,000 birds. The colony on Seagull Island, off the north-west coast of Melville Island, supports over 50,000 birds and is considered globally significant (DSEWPaC 2012a). The species forages in a range of habitats including shallow waters of lagoons, coral reefs, bays, harbours, inlets and estuaries; along shorelines; rocky outcrops in open sea; in mangrove swamps; and in offshore and pelagic waters (Higgins and Davies 1996, cited in DSEWPaC 2012d). Non-breeding aggregations of the crested tern are present all year round in the NMR, with breeding occurring consistently between March and July on the NT coastline (DSEWPaC 2012d).

A BIA for the crested tern has been designated at the northern tip of Melville Island, including a 20 km buffer from the breeding shoreline of Seagull Island noted as a foraging zone (DoEE 2017c). The primary breeding period on the island occurs between April and July.

Red knot

The red knot has been recorded from all Australian state/territory coastlines and commonly inhabits intertidal mudflats, sandflats and sandy beaches of sheltered coasts (DoE 2016f). The red knot breeds in the northern hemisphere and migrates along the East Asian-Australasian Flyway to spend the boreal winter in Australasia. The species is capable of flying non-stop along their migratory route and tends to use only a few staging areas (Bamford et al. 2008, cited in DoE 2016f). The species generally arrives in Australia from late August and departs northern Australia in late March/late April (DoE 2016f).

Sharp-tailed sandpiper

The sharp-tailed sandpiper is widely distributed across Australia and has been observed in freshwater/saline habitats at both inland and coastal locations (DoEE 2017e). The species forages along the edges of wetlands or intertidal mudflats. The sharp-tailed sandpiper arrives in Australia from their northern breeding grounds in mid-August-September with birds departing by April (DoEE 2017e).

Pectoral sandpiper

The pectoral sandpiper has a wide distribution across Australia and has been reported as occurring in Australia from September to June (DoEE 2017e). The species does not breed in Australia and is commonly found in coastal or near coastal habitats. The pectoral sandpiper’s preferred habitat is shallow fresh to saline wetlands, but it also occurs at estuaries, bays, saltmarshes and creeks.

Common sandpiper

The common sandpiper is widespread and has been recorded along all coastlines of Australian and in many areas inland (DoEE 2017e). The species generally arrives in Australia around July after migrating southward from breeding areas in Eurasia and commences its northward migration from February–May or early June (DoEE 2017e). The common sandpiper utilises a wide range of coastal wetlands and some inland wetlands and most commonly occurs around muddy margins or rocky shores (DoEE 2017e). The species generally forages in shallow waters or along the edges of wetlands.

5.6.4.3 Offshore islands

As outlined above, 45 migratory and/or marine bird species have been identified as potentially occurring or having habitat within the area of influence.

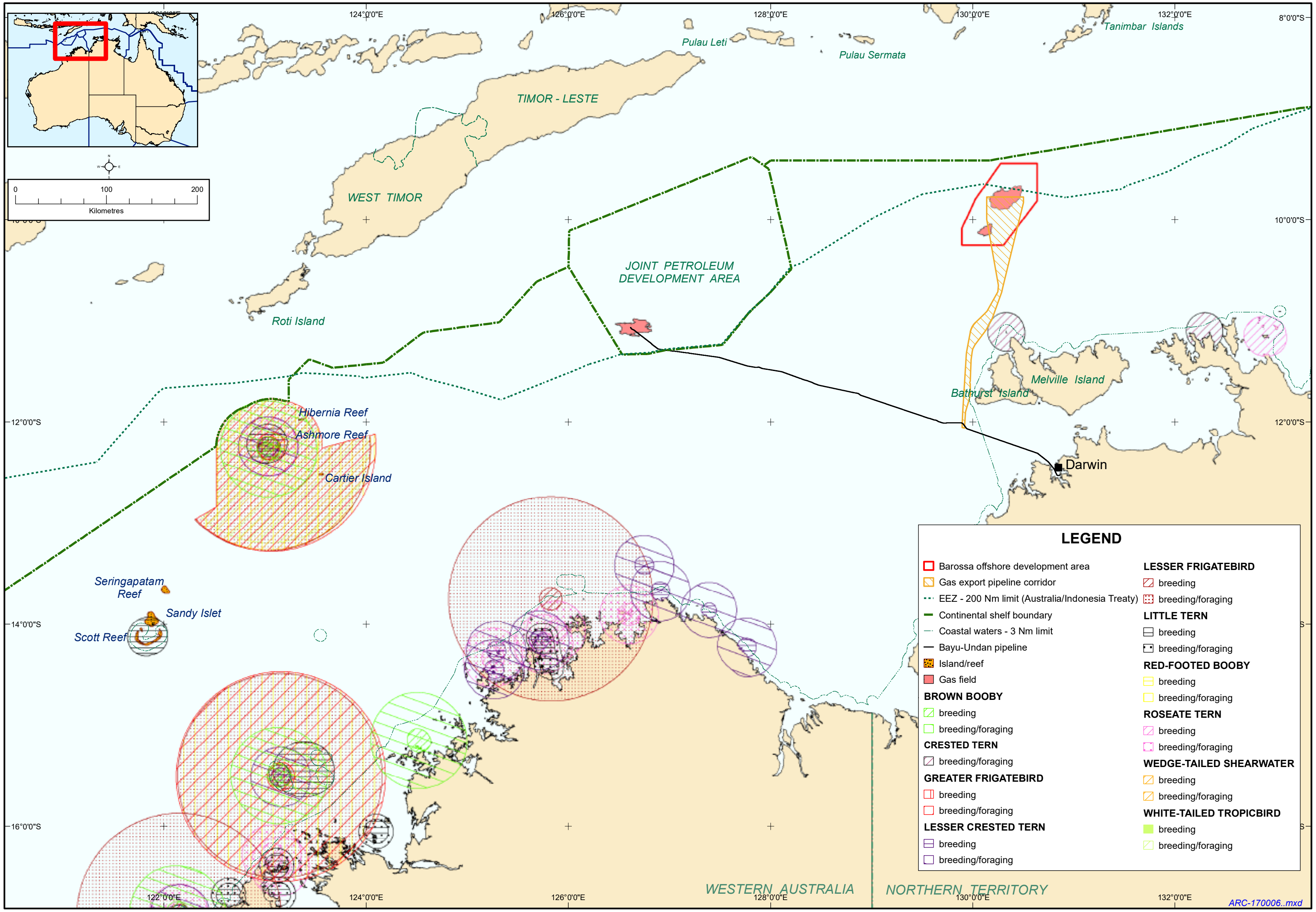
The Tiwi Islands, and small islands in the vicinity, support a large number of seabirds and migratory shorebirds. Refer to **Section 5.5.4** for further detail.

There are a few notable offshore island locations within the area of influence that support important seabird (e.g. terns, shearwaters, boobies, frigatebirds, noddy's and tropicbirds) and shorebird (e.g. sandpipers, barn swallow and greenshanks) feeding, breeding and nesting sites including Ashmore Reef and Cartier Island (Clarke 2010). There are also a number of BIAs for seabirds within the area of influence, as summarised in **Table 5-5** and shown in **Figure 5-19**.

Numbers of migratory shorebirds are highest between October and April, though large numbers of shorebirds are present year round as many species 'over winter' in their first years of life (Higgins and Davis 1996). The extensive sand flats exposed at low tide provide foraging opportunities for internationally significant species including the grey plover and sanderling (Swann 2005a, 2005b).

Table 5-5: BIAs for seabirds within the area of influence

Seabird species	BIA	General location(s)
Brown booby (*Sula leucogaster*)	Breeding/foraging	Ashmore Reef, Cartier Island, WA (Kimberley) coastline
Red-footed booby (*Sula sula*)		Ashmore Reef, Cartier Island, WA (Kimberley) coastline and adjacent offshore islands
Greater frigatebird (*Fregata minor*)		
Lesser frigatebird (*Fregata ariel*)		
Lesser crested tern (*Thalasseus bengalensis*)	Breeding	Ashmore Reef, Cartier Island, WA (Kimberley) coastline Through consultation with technical experts it is understood that this represents an error in existing literature. The lesser crested tern is mostly an inshore species and does not occur at Ashmore Reef of Cartier Islands (pers. comm. R. Clarke, Monash University, 2016).
Little tern (*Sternula albifrons*)	Breeding and resting	Breeding – WA (Kimberley) coastline Resting – Ashmore Reef Most individuals in offshore waters are migrants from Japan, however breeding birds from the Australian mainland also occur (pers. comm. R. Clarke, Monash University, 2016).
Roseate tern (*Sterna dougallii*)	Breeding	Ashmore Reef, WA (Kimberley) coastline
Wedge-tailed shearwater (*Ardenna pacifica*)	Breeding/foraging	Ashmore Reef, Cartier Island
White-tailed tropicbird (*Phaethon lepturus*)	Breeding	



(Source: National Conservation Values Atlas; DoEE 2017c)

Figure 5-19: Biologically important areas for seabirds

5.6.5 Fish

5.6.5.1 Regional overview

Fish communities occupy a range of habitats and play an important ecological role with many species being of conservation value and importance for commercial and recreational fishing.

The current state of knowledge of fishing activities in a socio-economic and indigenous (traditional) use context is discussed further in **Section 5.7.12** and **Section 5.7.13**.

A search of the EPBC Act Protected Matters database identified 35 fish species that may occur or have habitat in the project area (**Appendix P**). The whale shark (*Rhincodon typus*) is the only one of these species considered threatened (vulnerable) and migratory. The remaining 34 listed marine species are ray-finned fishes and are either pipefish or seahorses (family Syngnathidae). These species may pass through the offshore waters of the project but are more likely to be associated with the shallow waters around the nearby shoals/banks (**Section 5.5.2**) and close to the NT coastline where benthic communities provide suitable shelter and foraging habitats.

5.6.5.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Whale shark

Whale sharks (*Rhincodon typus*; vulnerable) are the largest species of fish in the world (DoEE 2017e). In Australia, whale sharks occur mainly off WA, particularly within the Ningaloo Marine Park. However, they are also known to occur off NSW, Queensland, NT, and occasionally South Australia, Victoria and Christmas Island, although records are limited (Compagno 1984; Last and Stevens 1994, in Pogonoski et al. 2002; Norman 1999). Whale sharks are known to be highly migratory, with studies demonstrating migrations of at least 13,000 km over 37 months (Eckert and Stewart 2001). Long-term information on the movement and distribution of whale sharks in Australia is limited (DPaW 2013), and is mostly centred on individuals recorded off the Ningaloo Marine Park and, therefore consistent migration pathways are yet to be identified.

The conservation advice for the whale shark highlights the 200 m isobath along the northern part of the WA coast as an important migration route, with migration occurring mainly between July and November (DoE 2015i). Whale sharks demonstrate aggregation patterns that are most likely associated with oceanographic features, including areas of upwelling and high productivity (Eckert and Stewart 2001). Whale sharks aggregate seasonally in coastal waters off the Ningaloo Marine Park between March and July each year, with the highest frequency of sightings occurring in April. Whale sharks are highly migratory and generally depart Ningaloo Reef sometime between May and June, travelling north-east along the continental shelf and then moving offshore into the north-eastern Indian Ocean (DEH 2005). The timing of this aggregation has been reported to coincide with the high levels of productivity associated with annual coral spawning, resulting in an increased planktonic biomass and a more active food chain in the waters adjacent to the Ningaloo Reef (Taylor 1996). Seasonal aggregation areas are also known in coastal waters off Christmas Island (between December and January) and in the Queensland Coral Sea (between November and December) (DEH 2005). A biologically important foraging area is recognised in open waters off the Kimberley coast (**Figure 5-15**; DoEE 2017c).

Due to their widespread distribution and highly migratory nature, whale sharks may occur — albeit in very low numbers — in the Barossa offshore development area and northern end of the gas export pipeline. There are no areas of biological importance recognised in the NMR for this species.

Other fish species

The Barossa offshore development area and gas export pipeline are likely to support offshore pelagic and demersal fish assemblages which are typical of those found in the NMR.

Although the tropical waters off the NT coast contain a diverse range (approximately 1,400 species) of fish with tropical Indo-West Pacific affinities, fish abundance is considered low in the deep, relatively featureless waters that characterise the Barossa offshore development area and surrounds. Approximately 20 types of ray-finned fish have been observed in the Barossa offshore development area in varying densities and diversities (Jacobs 2016c).

The shoals and banks located within, or in close proximity to, the gas export pipeline corridor (e.g. Goodrich Bank, Marie Shoal and Shepparton Shoal) are likely to attract a diverse range of fish species. It is expected that similar fish species to those described below surrounding Evans Shoal and Tassie Shoal will be present (**Section 5.6.5.3**).

5.6.5.3 Fish communities – Evans Shoal and Tassie Shoal

Detailed characterisation of the fish communities associated with Evans Shoal and Tassie Shoal was undertaken by AIMS in conjunction with the survey of benthic habitats (Heyward et al. 2017). The survey of fish community structure and abundance was conducted utilising SBRUVSs, which were deployed at 95 locations (72 at Evans Shoals and 23 at Tassie Shoal).

A total of 7,256 fish from 300 species were recorded and included a diverse range of demersal and semi-pelagic fishes, eels, sharks and rays (Heyward et al. 2017). The majority of the individual fish observed (approximately 91%), and consequently the most commonly recorded species (261 species), were perch-like fishes (Order Perciformes). The next most common fish were puffer and triggerfish (Order Tetraodontiformes) and herrings (Order Clupeiformes), which accounted for approximately 6% and 3% of individuals observed, respectively. It was noted that fish abundance was influenced most by the presence of any epibenthos on the seafloor and by calcareous reef composition of the substratum (Heyward et al. 2017).

Tassie Shoal displayed a higher diversity of fish when compared to Evans Shoal. Tassie Shoal was observed to support an average of 32 fish species while Evans Shoal was observed to support an average of 14 fish species (Heyward et al. 2017). The diversity and abundance was observed to decrease with increasing depth at both shoals, which is to be expected.

Heyward et al. (2017) commented that Tassie Shoal supported consistently high fish diversity and abundance that was similar to or greater than other shoals and reefs at similar depths around Australia, which had been surveyed by AIMS. For example, the closest shoals for comparison are the Margaret Harries Banks, which have been observed to support an average of 18–26 fish species (Heyward et al. 2017). The shoals surveyed in response to the Montara incident recorded an average of approximately 23 fish species. To provide context at an Australia-wide level, studies of the shoals of the Great Barrier Reef have recorded an average of 17 fish species (Heyward et al. 2017). AIMS suggested that the high diversity and abundance of fish observed at Tassie Shoal may be the result of the shoal's proximity to Indonesian fauna residing on the other side of the Timor Trench.

While no fish species listed under the EPBC Act were sighted during the AIMS survey, three of the species represent new records for Australia: undescribed emperor (*Lethrinus species*; not yet classified in scientific literature), and two parrotfish known to occur in Indonesia – yellowtail parrotfish (*Scarus hypselopterus*) and darktail parrotfish (*Scarus fuscodorsalis*).

The fish community comprised both shelf-based species normally found on reefs and some "oceanic" species, such as the spotted oceanic triggerfish (Heyward et al. 2017). Some commercially targeted fish species were recorded in low numbers in deeper waters and included the red emperor and goldband snapper. Heyward et al. (2017) commented that the numbers of large fish observed at the shoals were lower than expected for such habitats. This, in conjunction with the bait-shy behaviour displayed by the large-bodied cods, snappers and emperors, is consistent with fish communities exposed to both legal (regulated) and illegal (unregulated) trap and line fishing.

5.6.6 Sharks and rays

5.6.6.1 Regional overview

A search of the EPBC Act Protected Matters database identified 11 listed threatened/migratory shark/ray species that may occur in or have habitat in the area of influence. Of these total species, the shark/ray species listed as threatened (including four which are also listed as migratory) were the great white shark (*Carcharodon carcharias*; vulnerable), speartooth shark (*Glyphis glyphis*; critically endangered), northern river shark (*Glyphis garricki*; endangered), green sawfish (*Pristis zijsron*; vulnerable), largetooth sawfish (*Pristis*; vulnerable) and dwarf sawfish (*Pristis clavata*; vulnerable). The listed migratory species of shark/rays that may occur within the area of influence include the narrow sawfish (*Anoxypristis cuspidata*), longfin mako (*Isurus paucus*), shortfin mako (*Isurus oxyrinchus*), reef manta ray (*Manta alfredi*) and giant manta ray (*Manta birostris*). While not identified in the EPBC protected matters search, the grey nurse shark (*Carcharias taurus*; critically endangered/vulnerable) was observed during the Barossa marine studies program at a seamount approximately 18 km to the west of the Barossa offshore development area (**Section 5.5.5**).

There are no areas of biological importance recognised in the NMR for any of the shark species identified.

5.6.6.2 Key values and sensitivities of relevance to the Barossa offshore development area and gas export pipeline corridor

Great white shark

The great white shark (*Carcharodon carcharias*; vulnerable) is not known to have significant populations with regular migratory routes or breeding/foraging aggregations in the project area. Although the offshore waters of the Timor Sea are typically outside their preferred habitat of inshore reefs and shallow coastal bays, individuals are known to make open ocean excursions of several hundred kilometres and can cross ocean basins (e.g. from South Africa to the western coast of Australia) (Weng et al. 2007). No EPBC listed critical habitat or BIAs for great white sharks has been identified within the project area and area of influence.

Sightings of great white shark within the project area are not expected to be common. Their presence is likely to be limited to infrequent individuals transiting the broader marine environment, such as the area of influence.

Mako

The shortfin mako (*Isurus oxyrinchus*; migratory) and the longfin mako (*Isurus paucus*; migratory) are offshore epipelagic species found in tropical and warm-temperate waters. Both species occur in Australia in coastal waters off WA, NT, Queensland and NSW (DoEE 2017e) at depths ranging from shallow coastal waters to at least 500 m (Groeneveld et al. 2014). These species may migrate through the project area, particularly the southern end of the export pipeline corridor, and area of influence.

Speartooth shark and northern river shark

Within Australia, speartooth (*Glyphis glyphis*; critically endangered) and northern river sharks (*Glyphis garricki*; endangered) have predominantly been recorded in tidal rivers and estuaries in north and north-western Australia (DSEWPaC 2012e). The Commonwealth Recovery Plan for sawfish and river sharks identifies the primary habitat of speartooth sharks as large tropical river systems, with the majority of individuals inhabiting the tidal and estuarine sections of these rivers (DoE 2015j). Speartooth sharks have been found in all five river systems that flow into the Van Diemen Gulf in the NT (DoE 2015j). Based on physiological and life history similarities with bull sharks, it is assumed that adult speartooth sharks can also inhabit coastal waters (Stevens et al. 2005; Pillans et al. 2009, cited in DoE 2015j). While the life-cycle characteristics of the speartooth shark are largely unknown, pupping is thought to occur around October to December (Pillans et al. 2010, DSEWPAC 2012e).

The northern river shark appears to favour habitats that experience large tides (e.g. rivers, large tropical estuarine systems and macrotidal embayments), have fine muddy/silty substrates and high turbidity (DoE 2015j). The species also utilises inshore and offshore marine waters (DoE 2015j). Only adults have been recorded in marine environments while neonates, juveniles and sub-adults have been recorded in freshwater, estuarine and marine waters (DoE 2015j). Little is known about the breeding cycles, however limited observations suggest that northern river sharks give birth immediately before the wet season (around October) (Pillans et al. 2010, cited in DSEWPAC 2012e).

Based on the habitat preferences of these species and the location of the Barossa offshore development area and northern extent of the gas export pipeline (i.e. deep offshore marine environment), it is considered highly unlikely that speartooth or northern river sharks will occur within these areas in significant numbers. However, they may be found in the vicinity of the southern end of the gas export pipeline or within the area of influence in northern coastal waters.

Sawfish

Green sawfish (*Pristis zijsron*; vulnerable) are widely distributed in Australian waters and have been recorded in inshore marine waters, estuaries, river mouths, embayments and along sandy and muddy beaches (DoE 2015j). While the species has predominantly been recorded in inshore coastal areas, it has been recorded hundreds of kilometres offshore in relatively deep waters (up to 70 m) (Stevens et al. 2005). Short-term tracking of movement patterns has shown that green sawfish appears to have limited movements that are tidally influenced, and it is likely to occupy a restricted range of only a few square kilometres in the coastal fringe, with a strong association with mangroves and adjacent mudflats (Stevens et al. 2008). Pupping is thought to occur during the wet season (Peverell 2005, cited in DSEWPAC 2012e).

Largetooth sawfish (*Pristis pristis*; vulnerable) have been recorded in both inshore marine waters (including rivers and estuaries) and offshore waters up to 100 km from mainland Australia (DoE 2015j). Only adult largetooth sawfish have been observed in offshore waters, with records limited (DoE 2015j). In general, largetooth sawfish (particularly juveniles) appear to prefer sandy or muddy bottoms of shallow coastal waters, estuaries and river mouths, and the central and upper reaches of freshwater rivers and isolated water holes (DoE 2015j). As with the green sawfish, pupping is believed to occur during the wet season (DSEWPaC 2012a).

The dwarf sawfish (*Pristis clavata*; vulnerable) is considered to extend from the Pilbara coast in WA across northern Australia and into the Gulf of Carpentaria (Last and Stevens 1994; Stevens et al. 2008). The species generally inhabits shallow (2 m–3 m) coastal waters and estuarine habitats (DoE 2015j). The species breeds in estuarine or fresh waters during the wet season, with the adults then tending to move into marine waters (Peverell 2005 in Larson et al. 2006, cited in DSEWPAC 2012e). While it is unclear how far adults travel offshore, it is considered likely they inhabit a range within the coastal fringe of only a few square kilometres and display site fidelity (Stevens et al. 2008).

Narrow sawfish (*Anoxypristis cuspidata; migratory*) have been recorded in inshore marine or brackish waters in water depths up to 40 m (Great Barrier Reef Marine Park Authority 2012). While limited information is available on the narrow sawfish, it is thought that the species preferred habitat is on or near the seabed in shallow coastal waters and estuaries (Great Barrier Reef Marine Park Authority 2012). The distribution of the species in Australian waters is unknown, however, it is most common in the Gulf of Carpentaria with southward ranges extending to Broad Sound (Queensland) and the Pilbara coast (WA) (Great Barrier Reef Marine Park Authority 2012). Pupping is understood to coincide with the wet season (DSEWPaC 2012a).

Based on the habitat preferences of sawfish and the location of the Barossa offshore development area and northern extent of the gas export pipeline corridor (i.e. deep offshore marine environment), it is considered highly unlikely that sawfish will occur within these areas. However, they may be found within the southern end of the gas export pipeline corridor or area of influence in coastal waters off northern Australia.

Grey nurse shark

The grey nurse shark (*Carcharias taurus*) was not identified in the EPBC Protected Matters search but was recorded at a seamount approximately 18 km west of the Barossa offshore development area during the Barossa marine studies program (Jacobs 2016c). There are two known distinct populations of grey nurse sharks in Australia:

- East coast population: occurs from southern Queensland to southern NSW, with aggregations occurring at a number of reefs along the coastline. It is listed as critically endangered under the EPBC Act (DoEE 2017e).
- West coast population: occurs predominantly in the south-west coastal waters of WA (sub-tropical to cool temperate waters), however, the species has been recorded as far north as the North West Shelf (DoEE 2017e). It is listed as vulnerable under the EPBC Act.

It is unknown whether the individuals observed during the Barossa marine studies program would be linked to the east or west coast populations, or another discrete population.

The species is believed to be rare off the NT (Last and Stevens 1994) and has only been caught on one occasion in the Arafura Sea (Read and Ward 1986). In 2015 it was reported that four grey nurse sharks (three females and one male) were caught by local fishermen in the vicinity of Browse Island (approximately 800 km south-west of the Barossa offshore development area); representing the first known catches in the area (Momigliano and Jaiteh 2015).

While there is relatively little information about the grey nurse sharks' behaviour in Australian waters, the species is often observed in demersal waters above the seabed or near deep sandy-bottomed rocky caves, in the vicinity of inshore rocky reefs and islands (Otway and Parker 2000). It has been observed that at certain times of the year they appear to aggregate according to sex. For example, observational records indicate that females migrate southerly from central to south NSW and meet at aggregation hotspots, before returning to more northerly habitats (Otway and Parker 2000). It is also thought that the migration of sharks up and down the east coast is likely to be in response to water temperatures. Other observations from dive charter operations in NSW suggest that the species exhibits some degree of site fidelity as they regularly see grey nurse sharks in the same locations (Pollard et al. 1996). However, other studies along the WA coast suggest that individuals may not be restricted to particular localities or habitats (Chidlow et al. 2006). From this, it has been suggested that the west coast population may not aggregate to the same degree or in the same areas/habitat types as the east population (Chidlow et al. 2006).

Based on the findings of the Barossa marine studies program and the species' habitat preference, it is considered possible that individuals may be encountered in low numbers within the project area and area of influence.

Rays

The reef manta ray (*Manta alfredi*) is commonly sighted in or along productive nearshore environments, such as island groups, atolls or continental coastlines (IUCN 2015). However, the species has also been recorded around offshore coral reefs, rocky reefs and seamounts. Long term sighting records suggest that this species is mostly resident to tropical and subtropical waters (IUCN 2015). Individuals have been documented making seasonal migrations of several hundred kilometres between well-established aggregation sites (IUCN 2015).

The giant manta ray (*Manta birostris*) is common in tropical waters of Australia and primarily inhabits nearshore environments along productive coastlines with regular upwelling. However, they do appear to be seasonal visitors to coastal or offshore areas (e.g. islands, pinnacles and seamounts) (IUCN 2015).

The Barossa offshore development area is not located in or adjacent to any known key aggregation areas for these species (e.g. feeding or breeding). Based on the habitat preference of these species of rays and the location of the Barossa offshore development area (i.e. deep offshore marine environment with no significant benthic features), it is considered highly unlikely they will occur in significant numbers and would be restricted to individuals transiting through the area. However, they may be found within the southern extent of the gas export pipeline corridor given its proximity to coastal areas and the area of influence in the coastal waters of the north Kimberley.

5.7 Socio-economic and cultural environment

5.7.1 World Heritage properties

There are no World Heritage properties in, or in the immediate surrounds of, the project area. The nearest World Heritage Site is Kakadu National Park, which is approximately 315 km to the south-east of the Barossa offshore development area. While the majority of this site encompasses the NT mainland, the National Park includes the mangrove-fringed coast from Wildman River to East Alligator River and offshore islands of Barron Island and Field Island in the Van Diemen Gulf (DoEE 2017i).

Given the significant distance of the project from Kakadu National Park, and taking into consideration the modelling undertaken to inform this OPP (**Section 6.4.10**), no impacts to this value/sensitivity are anticipated. Therefore, World Heritage properties are not considered further in this OPP.

5.7.2 National Heritage places

There are no National Heritage properties in, or in the immediate surrounds of, the project area (DoEE 2017h). While significantly distant from the project area, the Ashmore Reef and Cartier Island National Nature Reserve (listed on the Register of National Estate; place identification: 14689), which is approximately 730 km south-west of the Barossa offshore development area, is within the area of influence. The reserve is a declared National Nature Reserve and Marine Protected Area under the EPBC Act, for the following features of nature conservation significance:

- Ashmore Reef has a rich and diverse marine life; specifically, the reef:
  - provides significant breeding and feeding habitat for marine turtles
  - is considered to have the world's greatest abundance and diversity of sea snakes
  - is an important seabird rookery and provides an important staging/feeding area for many migratory seabirds
  - provides breeding and feeding habitat for a small dugong population (< 50 individuals).
- Cartier Island and the surrounding waters support important seabird rookeries, many species of which are migratory and have their main breeding sites on the small isolated islands. The islands are also an important staging point and feeding area for numerous migratory seabirds. The island supports significant populations of feeding and nesting marine turtles and a high abundance and diversity of sea snakes.

5.7.3 Commonwealth Heritage places

The project is not located in, or in the immediate surrounds of, any Commonwealth Heritage places. While significantly distant from the project area, the Seringapatam Reef and Surrounds (place identification: 17567) and Scott Reef and Surrounds (place identification: 105480) Heritage places are located approximately 960 km and approximately 970 km, respectively, to the south-west of the Barossa offshore development area and are within the area of influence. These Heritage places are regionally important for the following features of conservation significance (DoEE 2017j):

- regionally important in terms of their high diversity of marine fauna, including corals, fish and marine invertebrates
- physical characteristics of the reefs create environmental conditions which are rare for shelf atolls, including clear deep oceanic water and large tidal ranges that provide a high physical energy input to the marine ecosystems
- high representation of species not found in coastal waters off WA and for the unusual nature of their fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific, as well as the reefs of the Indonesian region.

The area of influence also encompasses a portion of the Commonwealth Heritage place of the Ashmore Reef National Nature Reserve (place identification: 105218), which is described above in **Section 5.7.2**.

5.7.4 Declared Ramsar wetlands

There are no "Wetlands of International Importance" under the Convention on Wetlands of International Importance (Ramsar 1975) in, or in the immediate surrounds of, the project area. However, the area of influence encompasses Ashmore Reef, which is located approximately 750 km south-west of the Barossa offshore development area. Ashmore Reef was designated as a Ramsar wetland due to its importance in providing a resting place for migratory shorebirds and supporting large seabird breeding colonies (DoEE 2017k). A summary of the key ecological character of the Ashmore Reef Ramsar site, as outlined by Hale and Butcher (2013), are provided in **Table 5-6**.

Table 5-6: Summary of ecological character of the Ashmore Reef Ramsar site

Component	Description
Marine flora	Five species of seagrass recorded with *Thalassia hemprichii* dominant, comprising over 85% of total cover. Total cover of 470 ha of seagrass, but much of this is sparse and there is only 220 ha with a mean cover of >10%. Over 3,000 ha of macroalgae, mostly on the reef slope and crest areas. Algae dominated by turf and coralline algae with fleshy macroalgae comprising typically less than 10% of total algal cover.
Marine invertebrates	275 species of hard coral, covering an area of around 700 ha. 39 taxa of soft coral, covering an area of around 300 ha. Over 600 species of mollusc, including two endemic species. Over 180 species of echinoderm, including 18 species of sea cucumber. Sea cucumber density is highly variable, but on average exceeds 30 per hectare. 99 species of decapod crustacean.
Fish	Over 750 species of fish, including five species listed as threatened (squaretail leopard grouper (*Plectropomus areolatus*; vulnerable); humphead wrasse (*Cheilinus undulates*; endangered); humpback grouper (*Cromileptes altivelis*; vulnerable); green humphead parrotfish (*Bolbometopon muricatum*; vulnerable) and blacksaddled coral grouper (*Plectropomus laevis*; vulnerable). Three species of shark listed as threatened (snaggletooth shark (*Hemipristis elongate*; vulnerable), scalloped hammerhead (*Sphyrna lewini*; endangered) and squat-headed hammerhead (*Sphyrna mokarran*; endangered). Predominantly shallow water, benthic taxa that are common throughout the Indo-Pacific. Density of small reef fishes is around 20,000 to 40,000 per hectare. Low density of sharks (< 1 per hectare).
Sea snakes	Prior to listing there was a high diversity and population, peaking in 1998 with an estimated total population of 40,000 snakes at the site. However, by the time of listing in 2002 the site was on a trajectory of decline and diversity and abundance was low.

Component	Description
Turtles	Three species of marine turtle: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*), all of which are listed threatened species. Green turtles are the most abundant, with a total estimated population of around 10,000. Nesting by two species: green turtles and hawksbill turtles.
Seabirds and Shorebirds	72 species of wetland dependent birds recorded, with 47 species listed under international migratory agreements. Average of around 48,000 seabirds and shorebirds annually. Six species are regularly recorded in numbers >1% of the population. Nesting of 20 species, 14 of which regularly breed in the site.
Dugongs	Small but significant population, that may breed within the site.

The nearest Ramsar site to the project area is the Cobourg Peninsula, which encompasses an area of 220,700 ha (DoEE 2017k). The site is located approximately 200 km south-east of the Barossa offshore development area and approximately 176 km south-east of the gas export pipeline corridor at its closest point. Taking into consideration the modelling undertaken to inform this OPP and the project's area of influence, there is no risk of interaction with this Ramsar site. The Cobourg Peninsula Ramsar site boundary aligns with the Garig Gunak Barlu National Park boundary, and covers all wetlands of Cobourg Peninsula and nearby islands. The site includes freshwater and extensive intertidal coastal/marine ecosystems (such as dune communities, fringing coral reefs, rocky reefs/shores, sandy beaches, mudflats/saltflats, mangroves and seagrass communities), but excludes subtidal areas (DoEE 2107k). The site provides nesting habitat for marine turtles (green, flatback, leatherback, hawksbill, olive ridley and loggerhead turtles), and habitat for dugongs and several cetaceans, including the Australian snubfin dolphin, Indo-Pacific bottlenose dolphin, Indo-Pacific humpback, and the false killer whale (DoEE 2107k). The site also supports significant waterbird (seabird) breeding colonies and important feeding/nesting habitat for migratory shorebirds travelling along the East Asian Australasian Flyway (DoEE 2107k). Permanent billabongs and river channels provide dry season refugia for aquatic species as well as water-dependent terrestrial vertebrate species (e.g. birds, reptiles and frogs).

5.7.5 Commonwealth marine area

The project is located within the Commonwealth marine area, which includes *"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 NT waters. The Commonwealth marine area stretches from three to 200 nautical miles from the coast"* (DoEE 2017l). The southern end of the gas export pipeline corridor is in close proximity to the NT coastal waters boundary (**Figure 1-1**).

5.7.6 Australian marine parks

The Barossa offshore development area is not located within the AMPs which form part of the North AMP network (**Figure 5-20**). The Oceanic Shoals marine park is the closest marine reserve and is located approximately 10 km south of the Barossa offshore development area.

The gas export pipeline corridor traverses the Oceanic Shoals marine park, which is one of eight reserves within the North AMP network covering an area of 71,743 km^2. The Oceanic Shoals marine park is designated as entirely Multiple Use Zone (IUCN category VI) (DoEE 2017m). As discussed in **Section 3.5.2**, the Draft North Commonwealth Marine Reserves Network Management Plan (Director of National Parks 2017a) defines proposed changes to the zoning within the Oceanic Shoals marine park. However, current transitional management arrangements for the AMPs will continue to apply until such time that the draft management plans are finalised.

The Oceanic Shoals marine park is significant because it contains habitats, species and ecological communities associated with the Northwest Shelf Transition Province (Director of National Parks 2017a). The Oceanic Shoals marine park has a number of conservation values; specifically, it provides an important resting and internesting area for the flatback and olive ridley turtles, and an important foraging area for loggerhead and olive ridley turtles (DoEE 2017m). The marine park also includes four KEFs; the carbonate bank and terrace system of the Van Diemen Rise, carbonate bank and terrace system of the Sahul Shelf, pinnacles of the Bonaparte Basin, and shelf break and slope of the Arafura Shelf (Director of National Parks 2017a).

The following North and North-west AMPs are also of relevance to this project in the area of influence (see **Section 6.4.10**):

- *Arafura marine park:* covers a large area (22,924 km^2) and is comprised of a Multiple Use Zone (IUCN category VI) (DoEE 2017m). It is located appropriately 215 km (at its closest point from the project) and has a number of conservation values. Specifically, it provides an important internesting area for a number of marine turtle species and important foraging habitat for breeding aggregations of the migratory roseate tern (DoEE 2017m).
- *Arnhem marine park:* covers an area of 7,125 km^2 and is comprised of a Special Purpose Zone (IUCN category VI) (DoEE 2017m). It is located approximately 365 km east of the project (at its nearest boundary) and provides an important internesting area for flatback turtles (DoEE 2017m). The marine park also provides important foraging habitat for breeding aggregations of the crested tern, bridled tern and roseate tern.
- *Kimberley marine park:* covers a large area (74,469 km^2) and is comprised of a National Park Zone (IUCN category II), and Habitat Protection Zone (IUCN category IV, specifically intended to protect humpback whale calving) and Multiple Use Zone (IUCN category VI) (DoEE 2017m). It is located approximately 500 km south-west of the project (at its nearest boundary) and has a number of conservation values. Specifically, it provides important foraging areas for migratory seabirds, dugongs, dolphins, marine turtles and a migration pathway and nursery areas for humpback whales (DoEE 2017m).
- *Ashmore Reef marine park:* covers a reasonably small area (583 km^2) and is comprised of a Sanctuary Zone (IUCN category Ia) and a Recreational Use Zone (IUCN category II) (Commonwealth of Australia 2002; DoEE 2017m). It is located approximately 750 km south-west of the project (at its nearest boundary) and has a number of conservation values. Specifically, it provides an important area for a number of EPBC listed species, including sea snakes, turtles, dugongs and migratory seabirds (DoEE 2017m). Ashmore Reef also supports important cultural and heritage sites, such as Indonesian artefacts and grave sites.
- *Cartier Island marine park:* covers a reasonably small area (172 km^2) and is comprised of a Sanctuary Zone (IUCN category Ia) (Commonwealth of Australia 2002; DoEE 2017m). It is located approximately 730 km south-west of the project (at its nearest boundary) and has a number of conservation values. Specifically, it provides an important area for a number of EPBC listed species, including sea snakes, turtles and migratory seabirds (DoEE 2017m).

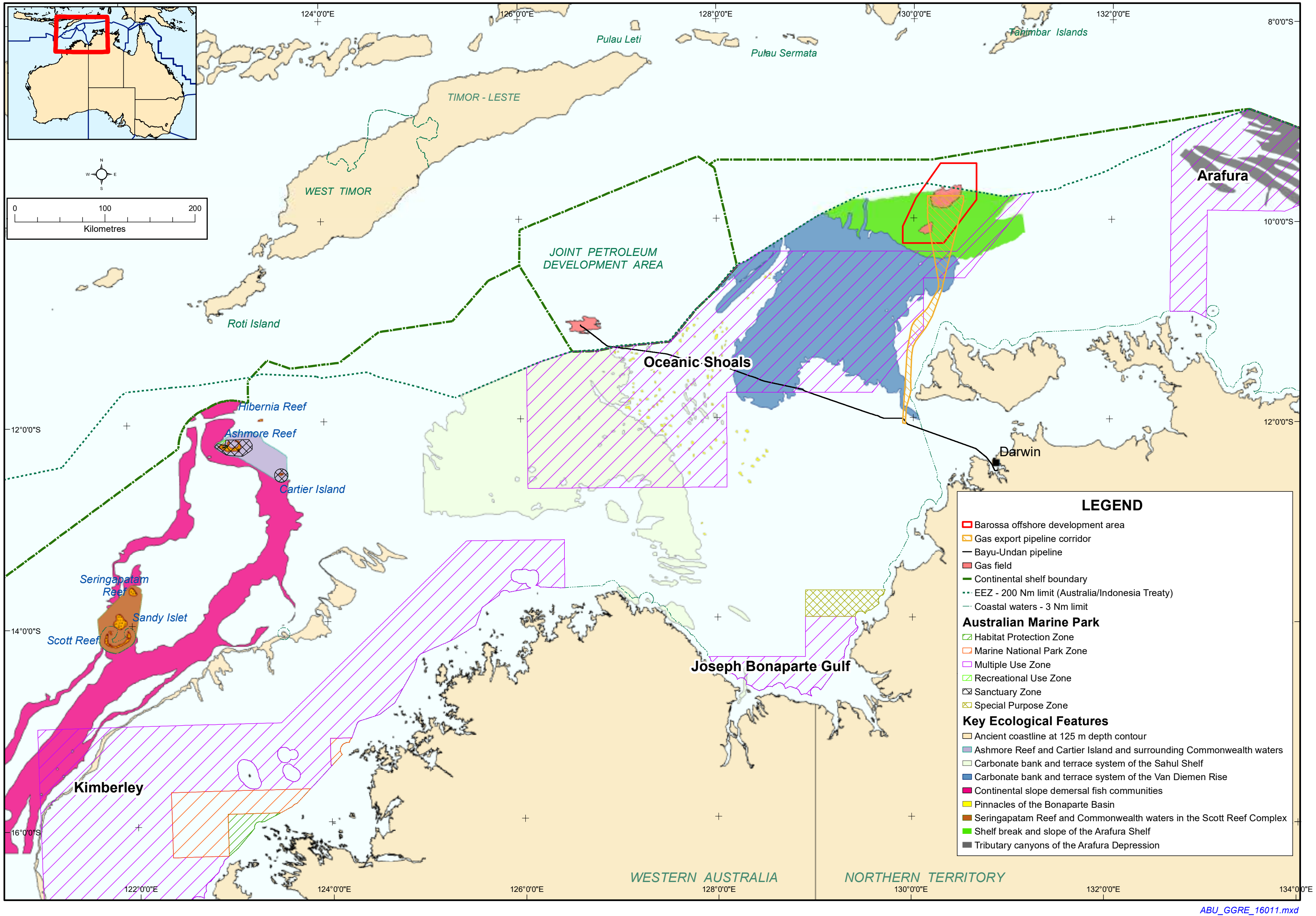


Figure 5-20: Australian Marine Parks and key ecological features

5.7.7 Listed threatened communities

There are no listed threatened communities, as defined under the EPBC Act, of relevance to the offshore context of this OPP.

5.7.8 Key ecological features

KEFs are considered to be of regional importance for either the marine region's biodiversity or ecosystem function and integrity. A search was conducted of the DoEE National Conservation Values Atlas to identify the KEFs of the Commonwealth marine environment that occur within or adjacent to the project area and area of influence (**Figure 5-18**). The results of the search are provided in **Table 5-7** (DSEWPaC 2012a, b, g, h).

Table 5-7: KEFs of relevance to the project

KEF	Values/description
Shelf break and slope of the Arafura Shelf	*Unique seafloor feature with ecological properties of regional significance* The shelf break and slope of the Arafura Shelf covers approximately 10,844 km^2 and is characterised by continental slope and patch reefs and hard substrate pinnacles. The ecosystem processes of the shelf break/slope are largely unknown. However, the ITF and surface wind-driven circulation are expected to influence nutrients, pelagic dispersal and species, and biological productivity in the region. Marine biota associated with the feature is largely of Timor–Indonesian Malay affinity. Records show at least 284 demersal fish species are found in the area, including commercially fished red snapper species (*Lutjanus erythropterus*). The area is also likely to support protected whale sharks, sharks and marine turtles. While the Barossa offshore development area occurs within the bounds of the KEF of the shelf break and slope of the Arafura Shelf, the ecological values associated with this unique seafloor feature (i.e. patch reefs and hard substrate pinnacles) were not observed during the Barossa marine studies program, nor are these topographically distinct features evident from the bathymetry data derived from multiple seismic surveys undertaken across this area (see **Section 5.4.3.1**).
Carbonate bank and terrace system of the Van Diemen Rise	*Unique seafloor feature with ecological properties of regional significance* The bank and terrace system of the Van Diemen Rise covers approximately 31,278 km^2 and forms part of the larger system associated with the Sahul Banks to the north and Londonderry Rise to the east. The feature is characterised by carbonate terrace, banks, channels and valleys, with variability in water depth and substrate composition considered to contribute to the presence of unique ecosystems in the channels. The variability in water depth and substrate composition across the feature may contribute to the presence of unique ecosystems in the channels. The carbonate banks and shoals found within the Van Diemen Rise make up 80% of the banks and shoals, 79% of the channels and valleys, and 63% of the terrace found across the NMR. The carbonate banks and shoals rise from depths of 100 m–200 m to within 10 m–40 m of the sea surface (Anderson et al. 2011). The feature provides habitat for a high diversity of sponges, soft corals and other sessile filter feeders; epifauna and infauna; and olive ridley turtles, sea snakes and sharks. Rich sponge gardens and octocorals have been identified on the eastern Joseph Bonaparte Gulf along the banks, ridges and some terraces. Plains and deep hole/valleys are characterised by scattered epifauna and infauna that include polychaetes and ascidians. Epibenthic communities such as the sponges found in the channels are likely to support first and second-order consumers. Pelagic fish such as mackerel, red snapper and a distinct gene pool of gold band snapper are found in the Van Diemen Rise. At its nearest point, this KEF is located approximately 3 km to the south-west of the Barossa offshore development area with a portion of this feature occurring within the gas export pipeline corridor.

KEF	Values/description
Pinnacles of the Bonaparte Basin	*Unique seafloor feature with ecological properties of regional significance* The pinnacles of the Bonaparte Basin cover more than 520 km^2 and are thought to be the eroded remnants of underlying strata. The pinnacles can be up to 50 m high and 50 km–100 km long and are thought to be the eroded remnants of the underlying strata. These vertical walls of the pinnacles are considered to generate local upwelling of nutrient-rich water, leading to phytoplankton productivity that attracts aggregations of planktivorous and predatory fish such as snapper, emperor, grouper and sawfishes, seabirds and foraging turtles. The pinnacles also provide areas of hard substrate in an otherwise relatively featureless environment and are, therefore, considered likely to support a high number of species, although further scientific information is required. This KEF is located approximately 150 km to the west south-west of the Barossa offshore development area and occurs within the area of influence.
Tributary canyons of the Arafura depression	*Unique seafloor feature with ecological properties of regional significance* The tributary canyons of the Arafura depression are around 80 m–100 m deep, 20 km wide and cover approximately 10,519 km^2. The canyons are an important feature as they are characterised by high ecological productivity and biodiversity of both benthic and pelagic habitats. Areas of high biodiversity and abundance generally correlate with harder substrates where sessile benthos such as sea whips and fans, soft corals, hydroids, crinoids and octocorals, some up to 50 cm in height, have been frequently found. In comparison, soft substrates tend to be associated with low-relief benthos that covers less than 5% of the surface area. The canyons are known to support a diverse array of invertebrates (e.g. sponges, corals, sea anemones, tunicates, worms, crustaceans, brittle stars and feather stars) and six small fish species. It is estimated that a further 500 species may be present, including species which endemic to the area. Water temperatures recorded in parts of the tributary canyons are generally higher (14–16 °C at approximately 230 m depth) than typical deep-sea environments (usually < 8 °C). However, despite these warmer temperatures, deep water fauna such as stalked crinoids, hexactinellid sponges and deep water pedunculate barnacles are known to occur. This KEF is located approximately 240 km to the east of the Barossa offshore development area and occurs within the area of influence.
Carbonate bank and terrace system of the Sahul Shelf	*Unique seafloor feature with ecological properties of regional significance* While there is limited scientific information available on the bank and terrace system of the Sahul Shelf, it is considered regionally important because of its likely ecological role in enhancing biodiversity and local productivity relative to its surrounds. The feature covers an area of approximately 41,158 km^2. The banks are characterised by hard substrate and flat tops at depths of 150 m–300 m, with each bank generally being < 10 km^2 in area and separated from each other by narrow meandering channels which are up to 150 m deep. The banks are thought to support a high diversity of organisms including reef-fish, sponges, soft and hard corals, gorgonians, bryozoans, ascidians and other sessile filter feeders. The banks are known to provide foraging areas for loggerhead, olive ridley and flatback turtles, with cetaceans and green and largetooth sawfish likely to occur in the area also. Warm water from the IFT is thought to drive nutrients from deepwater to shallower water up to 100 m in depth where sufficient light allows photosynthesis to occur. This KEF is located approximately 275 km to the south-west of the Barossa offshore development area and occurs within the area of influence.

KEF	Values/description
Continental slope demersal fish communities	*Communities with high species biodiversity and endemism* The demersal slope fish assemblages in the Timor Province, the Northwest Transition and the Northwest Province are characterised by high endemism and species diversity (more than 500 species, 76 of which are endemic). The level of endemism of demersal fish species in these bioregions is high compared to anywhere else along the Australian continental slope. The demersal fish species is made up of two distinct communities associated with the upper slope (water depths 225 m–500 m) and mid-slope (750 m–1,000 m). The KEF is located approximately 730 km to the south-west of the Barossa offshore development area and occurs within the area of influence.
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	*High productivity and aggregations of marine life* Ashmore Reef is the largest of only three emergent oceanic reefs present in the north-eastern Indian Ocean and is the only oceanic reef in the region with vegetated islands. Ashmore Reef and Cartier Island and the surrounding Commonwealth waters are regionally and internationally important for feeding and breeding aggregations of seabirds, marine reptiles and mammal populations; they represent areas of enhanced primary productivity. Seabird rookeries on the reef/island are known to support up to 50,000 seabirds (26 species) and up to 2,000 waders (30 species) seasonally. A number of migratory wading birds use the area as part of their migration between Australia and the Northern Hemisphere. Ashmore Reef also supports a high diversity of coral species. Species at Ashmore and Cartier include more than 225 reef-building corals, 433 molluscs, 286 crustaceans, 192 echinoderms, and 709 species of fish. Thirteen species of sea snakes occur in high numbers at Ashmore and Cartier reefs but are believed to have experienced recent declines (**Section 5.6.3**). An estimated 11,000 green and hawksbill turtles feed over seagrass beds present on reef flats throughout the year. Sandy beaches provide important habitat for nesting green and hawksbill turtles throughout the year. Seagrass present at Ashmore Reef provides critical breeding (April–May) and foraging (throughout the year) habitat for a genetically distinct population of dugong. The KEF is located approximately 750 km to the south-west of the Barossa offshore development area and occurs within the area of influence.
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 associated with the reefs themselves. The coral communities at Seringapatam and Scott Reefs play a key role in maintaining species richness and aggregations of marine life. The reefs and the waters surrounding them attract aggregations of marine life including humpback whales on their northerly migration, Bryde's whales, pygmy blue whales, Antarctic minke whales, dwarf minke whales, minke whales, dwarf sperm whales, spinner dolphins and whale sharks. Green and hawksbill turtles nest during the summer months on Sandy Islet on South Scott Reef. These species also internest and forage in the surrounding waters. Scott Reef is a particularly biologically diverse system and includes more than 300 species of reef-building corals, approximately 400 mollusc species, 118 crustacean species, 117 echinoderm species, around 720 fish species and several species of sea snakes. As two of the few offshore reefs in the north-west, they provide an important biophysical environment in the region. The KEF is located approximately 930 km to the south-west of the Barossa offshore development area and occurs within the area of influence.

KEF	Values/description
Ancient coastline at 125 m depth contour	*Unique seafloor feature with ecological properties of regional significance* The ancient submerged coastline, particularly areas characterised by hard rocky substrate, provide biologically important habitats in areas otherwise dominated by soft sediments. The escarpment is likely to support sponges, corals, crinoids, molluscs, echinoderms and other benthic invertebrates representative of hard substrate fauna in the North West Shelf bioregion. The topographic complexity of the escarpments also promotes vertical mixing of the water column, providing relatively nutrient-rich local environments. The enhanced productivity may attract opportunistic feeding by humpback whales, whale sharks and large pelagic fish. Therefore, this feature may provide sites for higher diversity and enhanced species richness. The KEF is located approximately 650 km to the south-west of the Barossa offshore development area and occurs within the area of influence.

The DoEE Commonwealth Marine Report Cards for the North and North-west Marine Regions (DSEWPaC 2012e, f) provide a high level analysis of the anthropogenic pressures on the KEFs. The analysis defines five categories in which each pressure impacts on the designated KEF including 'of concern', 'of potential concern', 'of less concern', 'not of concern' and 'data deficient or not assessed'. For the purposes of this OPP only pressures applicable to the project activities outlined in **Section 4** have been considered. A summary of the pressure analysis is detailed in **Table 5-8**, with further description provided below for the pressures 'of potential concern'.

Table 5-8: KEFs anthropogenic pressure analysis

Pressure	Physical habitat modification	Invasive species	Noise pollution		Light pollution		Marine debris	Oil pollution	
	Offshore construction	Vessels	Vessels	Offshore construction	Oil and gas infrastructure	Vessels	Vessels	Oil rigs	Shipping
Shelf break and slope of the Arafura Shelf	Of less concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Of potential concern	Of potential concern
Carbonate bank and terrace system of the Van Diemen Rise	Of less concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Not of concern	Not of concern
Pinnacles Bonaparte Basin	Of less concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Not of concern	Not of concern
Tributary canyons of the Arafura depression	Of potential concern	Of less concern	Not of concern	Not of concern	Not of concern	Not of concern	Of less concern	Of potential concern	Of potential concern
Carbonate bank and terrace system of the Sahul Shelf	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed
Continental slope demersal fish communities	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Of potential concern	Of potential concern	Of potential concern	Data deficient or not assessed
Seringapatam Reef and Commonwealth waters in the Scott Reef complex	Of potential concern	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Of potential concern	Of potential concern	Of potential concern	Data deficient or not assessed
Ancient coastline at 125 m depth contour	Not of concern	Not of concern	Of less concern	Of less concern	Data deficient or not assessed	Data deficient or not assessed	Data deficient or not assessed	Of less concern	Not of concern

Key

Red	Of concern
Yellow	Of potential concern
Green	Of less concern
Grey	Not of concern
(blank)	Data deficient or not assessed

Physical habitat modification

Physical habitat modification is a pressure 'of potential concern' for the tributary canyons of the Arafura depression and Seringapatam Reef and Commonwealth waters in the Scott Reef complex. These KEFs are the location of oil and gas resources including the Torosa Field below north and south Scott Reefs as well as the sites for a number of exploratory programs in both KEFs. The installation of infrastructure may directly affect the benthic communities associated with these KEFs. Activities known to occur in these KEFs with the potential to apply pressure to the physical habitat include construction, commissioning and operation of offshore oil and gas facilities, suspended solids from disturbance to seabeds and vessel anchorage.

The Barossa project infrastructure is located approximately 240 km and 930 km from the tributary canyons of the Arafura depression and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEFs respectively, and will not result in physical habitat modification to these features.

Invasive species

Invasive species have the potential to impact directly on benthic communities, coral and fish via competition for habitat and food resources. They are 'of potential concern' at two KEFs including Ashmore Reef and Cartier Island and surrounding Commonwealth waters, and Seringapatam Reef and Commonwealth waters in the Scott Reef Complex. The two key sources of invasive species introduction are ballast water exchange and vessel biofouling. Given the increased presence of oil and gas activities using many vessels in these KEFs they are susceptible to pressure from invasive species.

The project is located approximately 750 km and 930 km from the Ashmore Reef and Cartier Island and surrounding Commonwealth waters and Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEFs respectively. Vessels associated with the project will not be transiting in or near the sensitive features associated with these KEFs and therefore are highly unlikely to result in the introduction of invasive species.

Marine debris

Marine debris (i.e. persistent solid material) is of potential concern at Ashmore Reef and Cartier Island and surrounding Commonwealth waters and at Seringapatam Reef and the Commonwealth waters in the Scott Reef Complex. Although information on marine debris is limited, key sources for the introduction of marine debris (e.g. shipping, construction, commercial fishing, traditional Indonesian fishing vessels and illegal vessels) are present within these KEFs. The aggregations of marine biota identified as values associated with these KEFs (**Table 5-8**) could be adversely affected by ingestion of or entanglement with marine debris.

The project is located approximately 750 km and 930 km from the Ashmore Reef and Cartier Island and surrounding Commonwealth waters and Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEFs respectively. Marine debris and dropped objects associated with project activities are unlikely to materially affect seabed features associated with these KEFs.

Oil pollution

The North and North-west Marine Regions are areas subject to petroleum exploration, development and production and this is likely to increase. Shipping is likely to continue to expand in the region as a result of the growth of the resources sector. In particular, the shelf break and slope of the Arafura Shelf, tributary canyons of the Arafura depression, Ashmore Reef and Cartier Island and surrounding Commonwealth waters and Seringapatam Reef and Commonwealth waters in the Scott Reef complex KEFs contain habitats and species sensitive to the impacts from oil pollution.

The assessment of impact from oil pollution to the receptors within these designated KEFs in the area of influence is described in **Section 6.4.10**.

5.7.9 Commonwealth land

Commonwealth land includes land owned or leased by the Commonwealth or a Commonwealth agency, land in the external territories, and any other area of land that is included in a Commonwealth reserve (DSEWPaC 2013c).

Given the remote offshore location context of this proposal within Commonwealth waters, the consideration of Commonwealth land is only of relevance to this OPP in the context of Ashmore Reef and Cartier Island (at least 750 km away), with reference to the area of influence. These features are discussed in detail in **Section 5.5.4**.

5.7.10 European and Indigenous heritage

There are no recorded European or Indigenous heritage sites within the project area and given the water depths and distance offshore for most of the project area, the area is not expected to support any Indigenous heritage values. Considering traditional Indigenous fishing and subsistence activities are largely confined to inshore and coastal waters, these activities are not expected to occur in the project area. Therefore, it is considered highly unlikely that planned project activities within the project area will have any impact on Indigenous heritage values.

The Tiwi Islands have a number of sacred and significant sites that have heritage importance for both Tiwi and European people (**Figure 5-21**; Tiwi Land Council 2017). There are currently four registered sacred sites on the Tiwi Islands (Aboriginal Areas Protection Authority 2016). Another 56 sites of significance to Tiwi Islanders have been recorded, including two sites on the NT mainland (Tiwi Land Council 2003). The Tiwi Islands sites hold importance as they have high spiritual and cultural history value (Tiwi Land Council 2003).

As outlined in **Section 5.7.6**, Ashmore Reef is known to support important cultural and heritage sites, such as Indonesian artefacts (including ceramics and a relic cooking site) and grave sites which are located on the West, East and Middle Islands (Russell et al. 2004, cited in Hale and Butcher 2013; Commonwealth of Australia 2002). At least one Indonesian fisher is also buried on Cartier Island (Commonwealth of Australia 2002). It has been noted that the Indonesian cultural artefacts are deteriorating as a result of exposure to natural weathering processes (Commonwealth of Australia 2002).

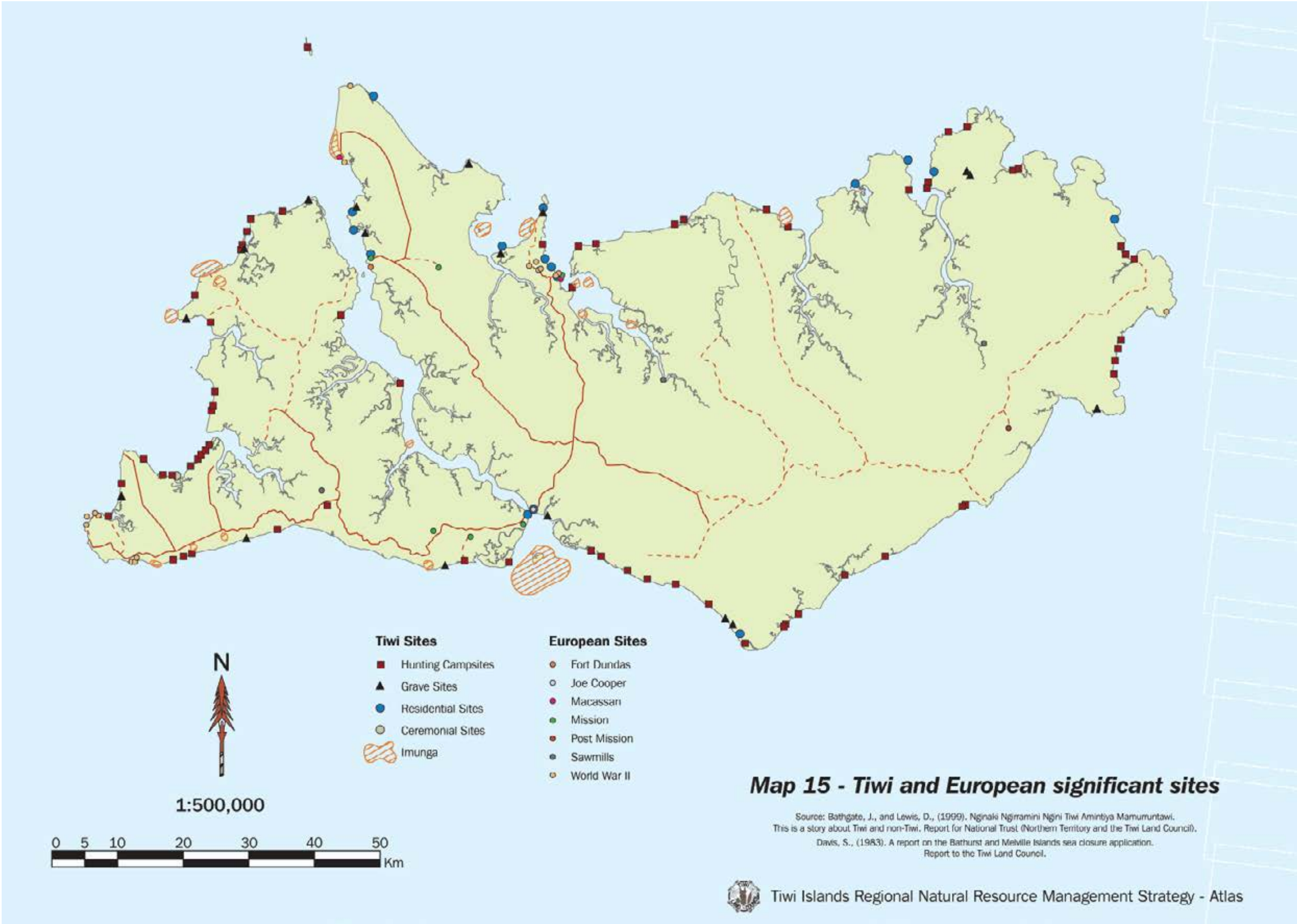


Figure 5-21: Significant Tiwi and European sites on the Tiwi Islands

5.7.11 Marine archaeology

There are no known shipwreck protected zones or shipwrecks within, or in the immediate surrounds of, the Barossa offshore development area, based on a search of the Australian National Shipwreck Database (DoEE 2017n).

Three historic shipwrecks are known to occur in the area of influence; a steamer ship (*Florence D*) that was sunk to the north-west of Bathurst Island, a steamer ship (*Don Isidro USAT*) that was sunk adjacent to the west coast of Bathurst Island, and a submarine *(I-124)* sunk in the Beagle Gulf. The vessels were sunk in 1942 during World War II and are listed under the *Historic Shipwrecks Act 1976*. The Florence D is located approximately 4.7 km east of the gas export pipeline corridor in water depths of 16 m, while the *Don Isidro USAT* is located approximately 9.7 km east of the gas export pipeline corridor in water depths of 6 m (DoEE 2017n). The submarine is located approximately 21 km east of the southern end of the gas export pipeline corridor in water depths of 42 m (DoEE 2017n). *Florence D* and the submarine *(I-124)* both have designated 797 m radial protection zones.

5.7.12 Commercial fisheries

Commercial fisheries considered of potential relevance to the project area were defined based on their proximity, specifically if their boundaries overlapped the project area, and whether they occurred within the area of influence. The details of the key fisheries are described below.

In summary, there are a number of fisheries in the region, with five currently active in the project area. Based on consultations to date, ConocoPhillips understand there are no areas of high fishing activity in the vicinity of the project.

Commonwealth managed fisheries

Five Commonwealth managed commercial fisheries, which are managed by the Australian Fisheries Management Authority (AFMA), overlap the project area and/or occur in the area of influence (**Figure 5-22**; AFMA 2017):

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

NT managed fisheries

Six NT managed commercial fisheries overlap the project area and/or occur in the area of influence (**Figure 5-23**; Department of Primary Industry and Fisheries (DPIF) 2017):

- Aquarium Fishery
- Coastal Line Fishery (gas export pipeline only)
- Demersal Fishery
- Offshore Net and Line Fishery
- Spanish Mackerel Fishery
- Timor Reef Fishery.

WA-managed fisheries

Three WA managed commercial fisheries occur within the area of influence (**Figure 5-23**; Department of Fisheries (DoF) 2015):

- Mackerel Managed Fishery
- Northern Demersal Scalefish Managed Fishery (NDSF)
- Northern shark fisheries – comprising the state managed WA North Coast Shark Fishery in the Pilbara and western Kimberley, and the Joint Authority Northern Shark Fishery in the eastern Kimberley.

A summary of the commercial fisheries is provided in **Table 5-9**.

Table 5-9: Commercial fisheries of potential relevance to the project

Commercial fishery	Context		Description
	Project area	Area of influence	
Commonwealth managed			
Northern Prawn Fishery (managed by AFMA)	✓	✓	The Northern Prawn Fishery management area extends over the Australia's northern coast, between Cape York in Queensland and Cape Londonderry in WA, from the low water mark to the outer edge of the Australian Fishing Zone (AFZ) (AFMA 2017). The majority of the fishing effort within the Northern Prawn Fishery occurs in the southern and western areas of the Gulf of Carpentaria, Joseph Bonaparte Gulf and along the Arnhem Land coast (Department of Agriculture and Water Resources (DoAWR) 2016). The key target species are banana prawns, tiger prawns and endeavour prawns. There are two fishing seasons, with the season end date depending on catch rates (AFMA 2017): • Season 1 (mainly banana prawns caught): 1 April – 15 June • Season 2 (mainly tiger prawns caught): 1 August – end of November There are currently 52 boats operating with statutory fishing rights (DoAWR 2016). A total of 8,189 boat-days were reported in the 2013 fishing season (DoAWR 2016). The areas of low, medium and high fishing effort are distant from the Barossa offshore development area (> 64 km). A portion of the gas export pipeline corridor overlaps an area of low fishing effort to the east of the Tiwi Islands (**Figure 5-24**). In general, there is little to no activity in the Northern Prawn Fishery in water depths > 100 m.
NWSTF		✓	The NWSTF extends eastward from 114° E to about 125° E off the WA coast between the 200 m isobath and the outer limit of the Australian Fishing Zone, but not taking into account Australian–Indonesian Memorandum of Understanding (MoU) (DoAWR 2016). The principal species fished are scampi, mixed snappers, deepwater prawns and mixed finfish, however, the NWSTF has predominantly been a scampi fishery in recent years (DoAWR 2016). A total of four fishing permits have been allocated to the entire NWSTF area in 2012–2013 (DoAWR 2016). Only one or two vessels have been active in the area in recent fishing seasons since 2008–2009 (DoAWR 2016). The fishing season is between June to July and December to April. Considering the location of the fishery, and low levels of active fishing, planned operations associated with the project are not expected to affect the NWSTF. Consultation undertaken in 2015/2016, in relation to an appraisal drilling campaign and 3D seismic survey, with this fishery did not identify any concerns.

Commercial fishery	Context		Description
	Project area	Area of influence	
Southern Bluefin Tuna Fishery (managed by AFMA)	✓	✓	The Southern Bluefin Tuna Fishery operates around Australia and extends to the high seas fishing zone (out to 200 nm from the coast) (AFMA 2017). Although the fishery extends across the project area, no fishing was undertaken in this area in 2014–2015 (DoAWR 2016). Fishing activity is focused in southern Australian states of South Australia and Victoria (DoAWR 2016). Therefore, while the management area overlaps the project, no activity is expected within the project area or area of influence.
Western Skipjack Tuna Fishery (managed by AFMA)	✓	✓	Skipjack tuna are widely distributed throughout tropical waters of the Indian and Pacific Oceans. Two stocks of skipjack tuna are thought to exist in Australian waters: one on the east coast and one on the west coast (DoAWR 2016). Skipjack tuna is the only target species in the fishery. Although 14 fishing permits have been allocated within the Western Skipjack Tuna Fishery, no fishing activity has been undertaken since 2008–2009 (DoAWR 2016). Therefore, the project is not expected to affect this fishery. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign and 3D seismic survey in the Barossa Field area, did not identify any concerns.
Western Tuna and Billfish Fishery (managed by AFMA)	✓	✓	The Western Tuna and Billfish Fishery management area extends over a large area westward from Cape York Peninsula (142°30′ E) off Queensland, around the west coast of WA and eastward, across the Great Australian Bight to 141°E at the South Australian/Victorian border (AFMA 2017). The fishery has operated at low levels of effort since the early 2000s due to economic conditions, with less than five vessels active in the fishery each year since 2005 (DoAWR 2016a). In recent years, effort has concentrated off south-west WA and South Australia (DoAWR 2016). Target species include bigeye tuna, yellow fin tuna, broadbill swordfish and striped marlin (AFMA 2017). While the management area overlaps the project, this fishery is not considered to be active within the area.

Commercial fishery	Context		Description
	Project area	Area of influence	
NT-managed			
Aquarium Fishery	✓	✓	The Aquarium Fishery is a small-scale, multi-species fishery that prospects freshwater, estuarine and marine habitats to the outer boundary of the AFZ. The harvest of most marine species occurs within 100 km of Nhulunbuy and Darwin (DPIF 2017a), though one license holder does collect from two offshore locations; Evans Shoal and Lynedoch Bank. During September to May the licence holder rotates between the shoal/bank for one week each month. There are only 12 aquarium fishing/display fishery licensees (DPIF 2015). Fishing activities may occur year-round. However, the licence holder collecting from the offshore locations advised that they are unlikely to be operating in the months of June to August due to the inclement weather conditions at that time of the year. Aquarium fishing/display fishery licensees can use barrier, cast, scoop, drag and skimmer nets, hand pumps, freshwater pots and hand-held instruments to collect aquarium species. The catch is collected by divers that rely on surface-supplied air from a vessel (DPIF 2015). The commercial catch can be separated into invertebrates and finfish. Invertebrate catch is mainly comprised of hermit crabs, various snails, whelks and more recently hard and soft corals. The finfish catch is diverse but predominantly consists of rainbowfish, catfishes and scats (DPIF 2017a). While the Aquarium Fishery overlaps the project, significant interactions between the fishery with the project are not expected as fishing activities offshore are primarily focused around shoals/banks which are distant from the Barossa offshore development area.
Coastal Line Fishery (jointly managed by the Northern Territory Fisheries Joint Authority (NTFJA) and the Fisheries Division of the NT DPIF)	✓ (gas export pipeline only)	✓	The fishery extends along the NT coast from the high water mark to 15 nm from the low water mark, with some restrictions in place around registered Aboriginal sacred sites and protected areas (DPIF 2017a). The majority of the fishing activity is concentrated around rocky reefs along the coastline within 150 km of Darwin (DPIF 2015). The fishery comprises commercial, recreational, charter and Indigenous sectors and there is considerable overlap in the range of species harvested. The commercial sector predominantly targets black jewfish and golden snapper with key secondary species including emperors, cods and other snappers (DPIF 2014). The fishery is restricted to 52 licences with approximately one third of these being active in 2015 (Northern Territory Seafood Council (NTSC) 2016a). Only eight licences have quota to fish in the western zone, which is west of Cobourg Peninsula. Fishing activities occur year round. Considering that fishing activity is mainly focused around rocky reefs along the Darwin coast, some fishing may occur in the vicinity of the southern end of the gas export pipeline corridor.

Commercial fishery	Context		Description
	Project area	Area of influence	
Demersal Fishery (jointly managed by the NTFJA and the Fisheries Division of the NT DPIF)	✓	✓	The fishery extends from waters 15 nm from the coastal waters mark to the outer limit of the AFZ, excluding the area of the Timor Reef Fishery (DPIF 2017a). The main target species of the fishery are red snappers and goldband snappers with key bycatch species being painted sweetlip, red emperor and cods (DPIF 2017a). In 2012, eight active licences (using eight vessels) fished for 980 boat-days in the fishery (DPIF 2014). There are currently 19 licences issued for the fishery, with around nine active (NTSC 2016b). The fishery operates year round. Fish traps, hand lines and droplines are permitted throughout the fishery and demersal trawl nets are permitted in two defined zones (**Figure 5-23**) (DPIF 2017a). The semi-demersal trawl zones does not overlap the project area, with the closest zone in the Joseph Bonaparte Gulf located approximately 36 km to the south-west of the southern end of the gas export pipeline. The fishery does not overlap the Barossa offshore development area. However, some fishing effort (though not using trawling techniques) may occur within the gas export pipeline corridor. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign in the Barossa Field, did not identify any concerns.
Offshore Net and Line Fishery (jointly managed by the NTFJA and the Fisheries Division of the NT DPIF)	✓	✓	The fishery covers an area of over 522,000 km^2 and extends from the NT high water mark to the boundary of the AFZ (DPIF 2017a). The majority of the fishing effort is in the coastal zone (within 12 nm of the coast) and immediately offshore in the Gulf of Carpentaria (DPIF 2017a). Limited effort was undertaken in the outer offshore area of the fishery during 2012, which is consistent with previous years (DPIF 2014). The target species of the fishery are blacktip sharks and grey mackerel, with a variety of other sharks and pelagic finfish caught as byproduct (DPIF 2017a). The number of licences for the fishery is restricted to 17(DPIF 2017a) and only 10 boats operated in 2015 (DoAWR 2016). In 2015, 405 boat-days were spent fishing, representing a 32% decrease from effort levels in 2014 (DoAWR 2016). The effort was also well below the peak of 1,801 boat-days recorded in 2003. The decline in fishing effort is thought to be due to a drop in shark fin prices (NT Government 2015, cited in DoAWR 2016) Given the large area of the fishery and that the majority of the fishing effort is within 12 nm of the coast, interactions between the fishery associated with the project are not expected to occur. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign and 3D seismic survey in the Barossa Field area, did not identify any concerns.

Commercial fishery	Context		Description
	Project area	Area of influence	
Spanish Mackerel Fishery (jointly managed by the NTFJA and the Fisheries Division of the NT DPIF)	✓	✓	The fishery extends from the NT waters seaward off the coast and river mouths to the outer limit of the AFZ (DPIF 2015a). The majority of the fishing effort occurs in the vicinity of reefs, headlands and shoals and includes waters near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt, the Sir Edward Pellew Group of islands and suitable fishing grounds on the western and eastern mainland coasts (DPIF 2017a, DPIF 2015). The target species of the fishery is the narrow-barred spanish mackerel, however, a small number of other mackerels are also taken. In 2012, there were 16 fishery licences of which 12 were actively operating (DPIF 2014). The 2012 fishing effort was 719 boat-days; a decrease from 813 boat-days in 2011 but an increase from the 672 boat-days in 2010 (DPIF 2014). Some fishing may occur in the vicinity of the southern end of the gas export pipeline. However, the fishery is not expected to be active in the Barossa offshore development area. Consultation undertaken in 2015/2016 with this fishery, in relation to an appraisal drilling campaign and 3D seismic survey in the Barossa Field area, did not identify any concerns.

Commercial fishery	Context		Description
	Project area	Area of influence	
Timor Reef Fishery (jointly managed by the NTFJA and Fisheries Division of the NT DPIF)	✓	✓	The Timor Reef Fishery operates in remote offshore waters in the Timor Sea in a defined area approximately 370 km north-west of Darwin. The fishery encompasses extends north-west of Darwin to the WA-NT border and to the outer limit of the AFZ and covers an area of approximately 28,811 km² (DPIF 2017a). The target species is goldband snapper, with other tropical snappers such as crimson snapper and saddletail snapper also consisting of part of the catch. The majority of the fishing effort is undertaken using drop-lines and occurs primarily in the 100 m–200 m depth range. Data for the period 1995–2004 shows that the highest commercial productivity for drop-line catch is very localised and is predominantly associated with the shelf geomorphic unit, in the 110 m–120 m depth range (Lloyd and Puig 2009). These depth ranges intersect the southern portion of the Barossa offshore development area (**Figure 5-25**). **Figure 5-25** shows that the southern portion of the Barossa offshore development area overlaps the highest productivity zones for the drop-line catch. Consultation undertaken with the commercial fishermen who operate in the Timor Reef Fishery, for the 2016 Caldita-Barossa 3D seismic survey, identified that in recent times fishing effort has increased to the south-west area of the fishery (at least 50 km from the Barossa offshore development area). There is no closed season for the Timor Reef Fishery, however, the fishery is normally most productive between October and May. There is less activity during the dry season months of June to August as strong northerly winds often prevent fishermen going to sea. There are currently 15 licences issued for the fishery (DPIF 2017a). These licences are held by three individual fishers. In 2012 seven vessels actively fished over a period of 938 boat-days, an increase of 14 boat-days from 2011 (DPIF 2014). Stakeholder consultation undertaken with DPIF and the NTSC in 2016, for the appraisal drilling campaign, confirmed there are only two active fishers currently operating in the fishery. One fisher is using traps to target goldband snapper in water depths between 80 m–150 m (maximum of 250 m) along reef fronts and on sand flats located near pinnacles. The other active licence holder is currently using trawl gear as part of a gear trial.

Commercial fishery	Context		Description
	Project area	Area of influence	
Mackerel Managed Fishery		✓	The Mackerel Managed Fishery in WA extends from the West Coast Bioregion (which runs from east Augusta to north of Kalbarri) to the WA–NT border within state waters (the coastline out to 3 nm) (DoF 2015. The fishery is divided into three fishing areas; Area 1 (Kimberley), Area 2 (Pilbara) and Area 3 (Gascoyne/West Coast) (DoF 2015). During 2014–2015, 14 licenses were allocated in Area 1 (Kimberley). Licence holders are only allowed to only fish for mackerel by trolling or handline (DoF 2015). A total of 11 boats operated in 2013, with three vessels operating in Area 1 (Kimberley) (DoF 2015). A total of 673 fishing days of effort were reported in 2014, with more than 53% of these days in Area 1 (Kimberley). The higher fishing effort in the Kimberley reflects the tropical distribution of mackerel species. Commercial fishers target Spanish mackerel in coastal areas around reefs, shoals and headlands (DoF 2015) and, as such, the shoals/banks in proximity to the project may be subject to commercial mackerel fishing. The interaction of this fishery with the Barossa project is only of relevance to the area of influence.
NDSF		✓	The fishery operates in waters off the Kimberley coast adjacent to the state of WA out to 200 nm (Commonwealth and state waters). The fishery is divided into two fishing area; Area 1 (inshore) and Area 2 (offshore) (DoF 2015). Area 2 (offshore) is further divided into three zones; Zone A represents the inshore developmental area; Zone B comprises the area with most of the historical fishing activity; while Zone C represents an offshore deep slope developmental area (water depths > 200 m) (DoF 2015). The target species for the NDSF are the goldband snapper and red emperor and the fishing season is unrestricted, therefore, fishing occurs year round. Eleven licenses for fishing within Zone C have been issued and the allowable effort allocated for these licences is used by eight vessels (DoF 2015). In 2014, the annual effort capacity was 616 fishing days for Zone A, 986 fishing days in Zone B and 1,100 fishing days for Zone C (offshore waters > 200 m) (DoF 2015). The interaction of this fishery with the Barossa project is only of relevance to the area of influence.
Northern Shark Fisheries		✓	The northern shark fisheries comprise the state managed WA North Coast Shark Fishery in the Pilbara and western Kimberley, and the Joint Authority Northern Shark Fishery in the eastern Kimberley. The Northern Shark Fishery has not operated since 2008–2009 (DoAWR 2016). Given the distance to the project, and that the fishery is not active, interactions are not expected to occur.

NT reef-fish protection areas

The NT DPIF (Fisheries Research division) have undertaken a review of the status of golden snapper and jewfish stocks and identified that stocks of these species have continued to decline, particularly at an accelerated rate in the greater Darwin area (DPIF 2017b). To address this issue, NT DPIF have proposed a system of protection areas that, combined with angler education, possession and vessel limits should achieve the necessary catch reductions needed to promote stock recovery (DPIF 2017b). There are five reef-fish protection areas; Bathurst Island, Melville Island, Charles Point Wide, Lorna Shoal and Moyle/Port Keats (**Figure 5-23**). These reef fish protection areas are temporary and will remain for at least five years (DPIF 2017b).

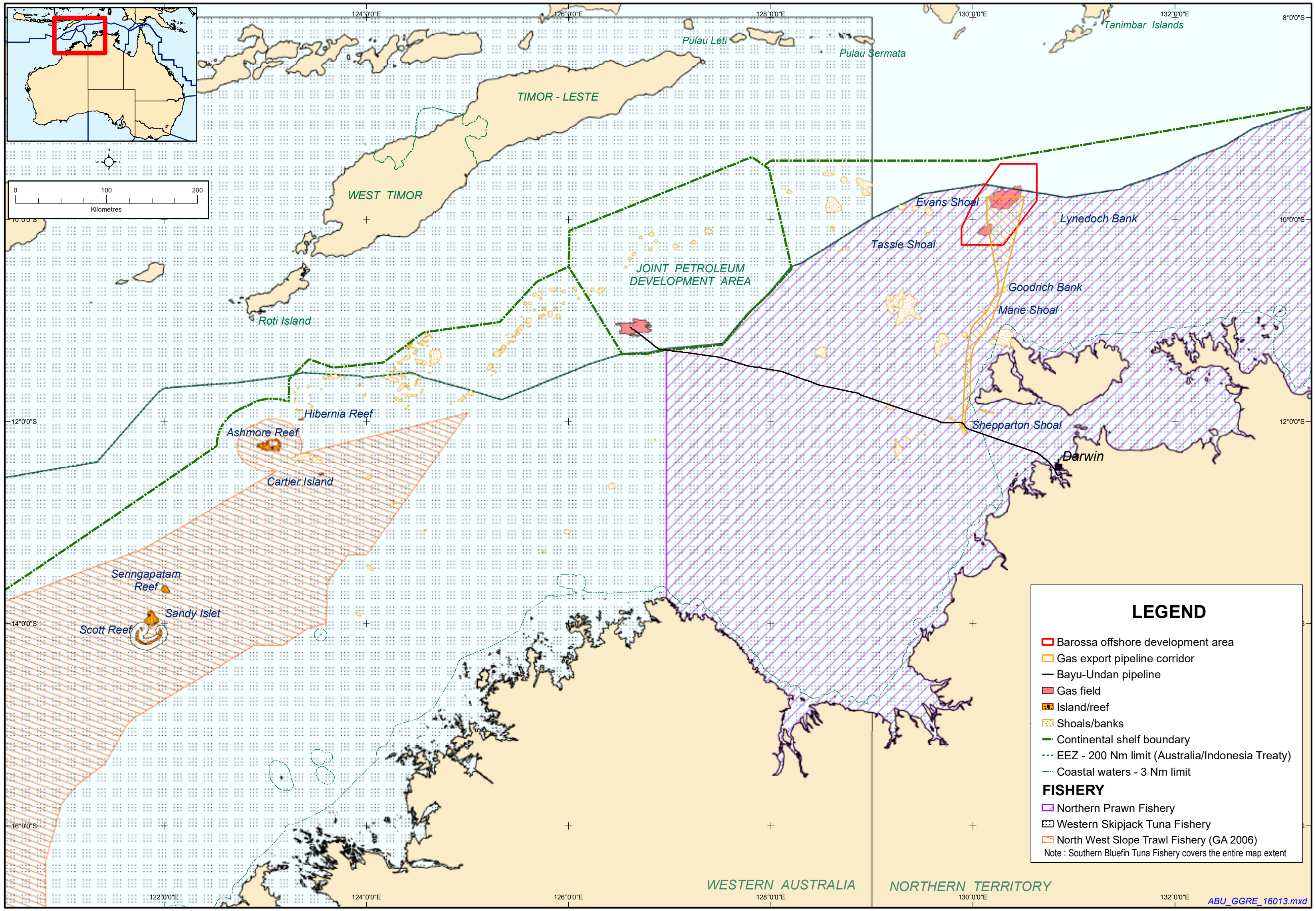


Figure 5-22: Commonwealth managed commercial fisheries

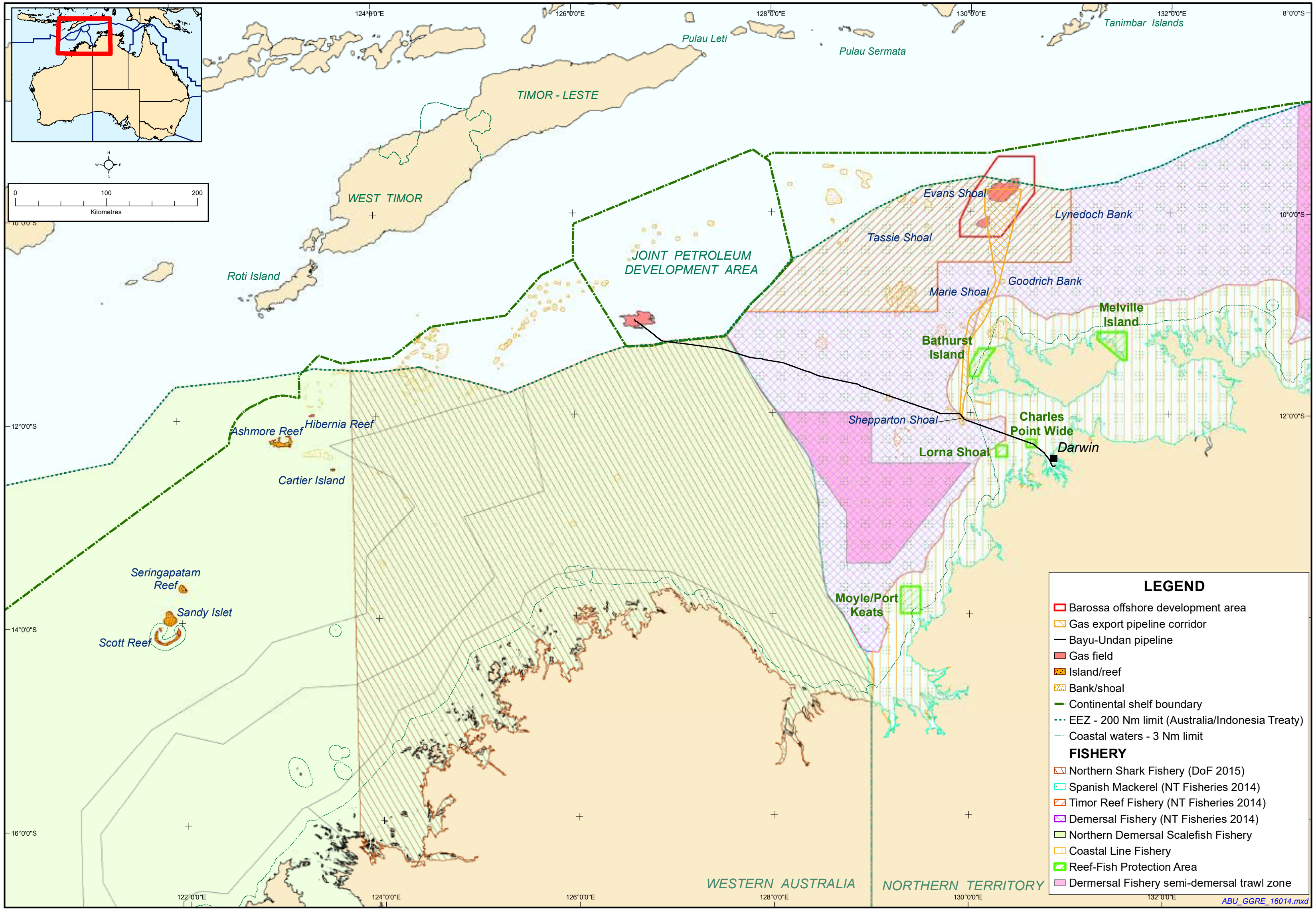
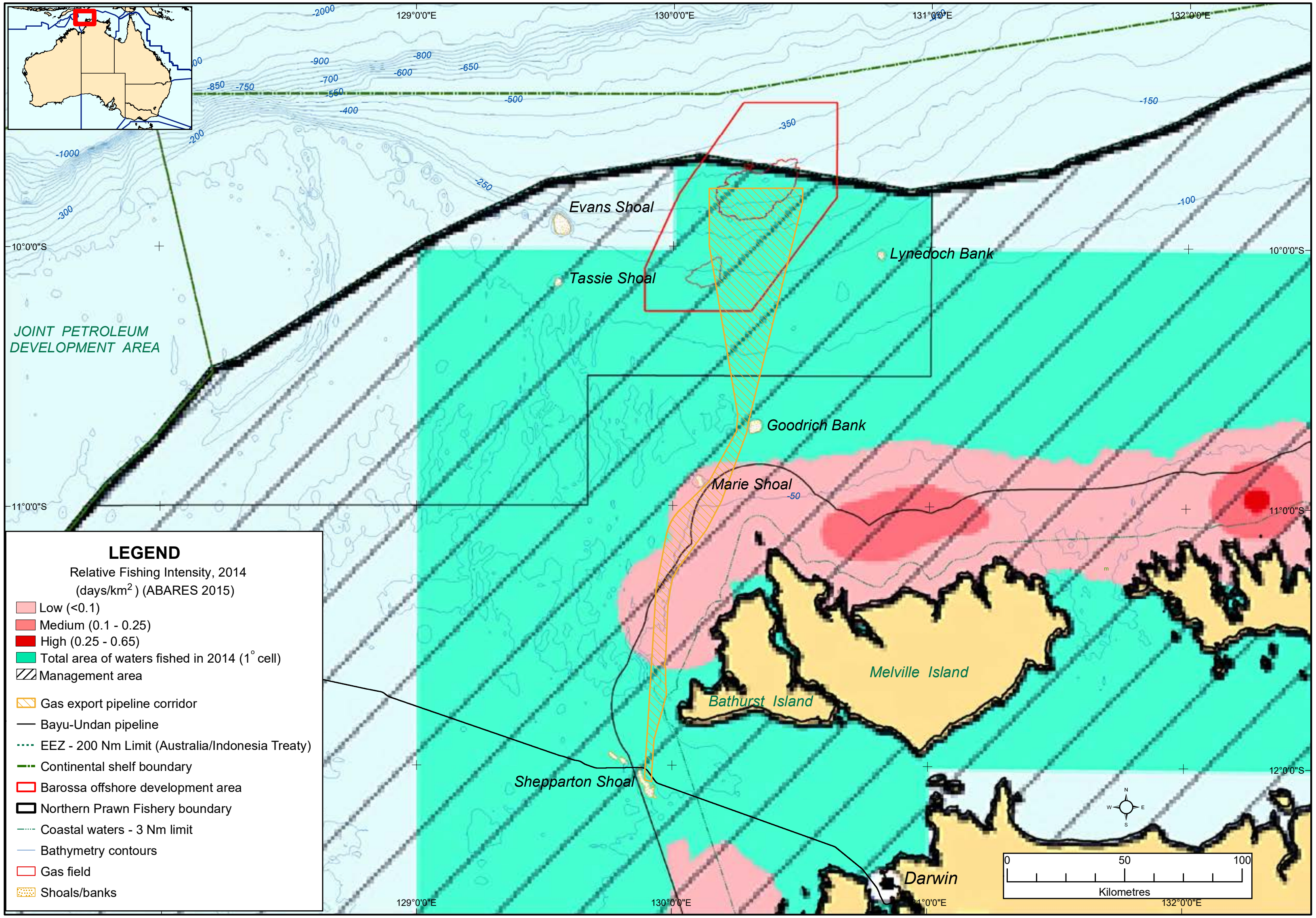
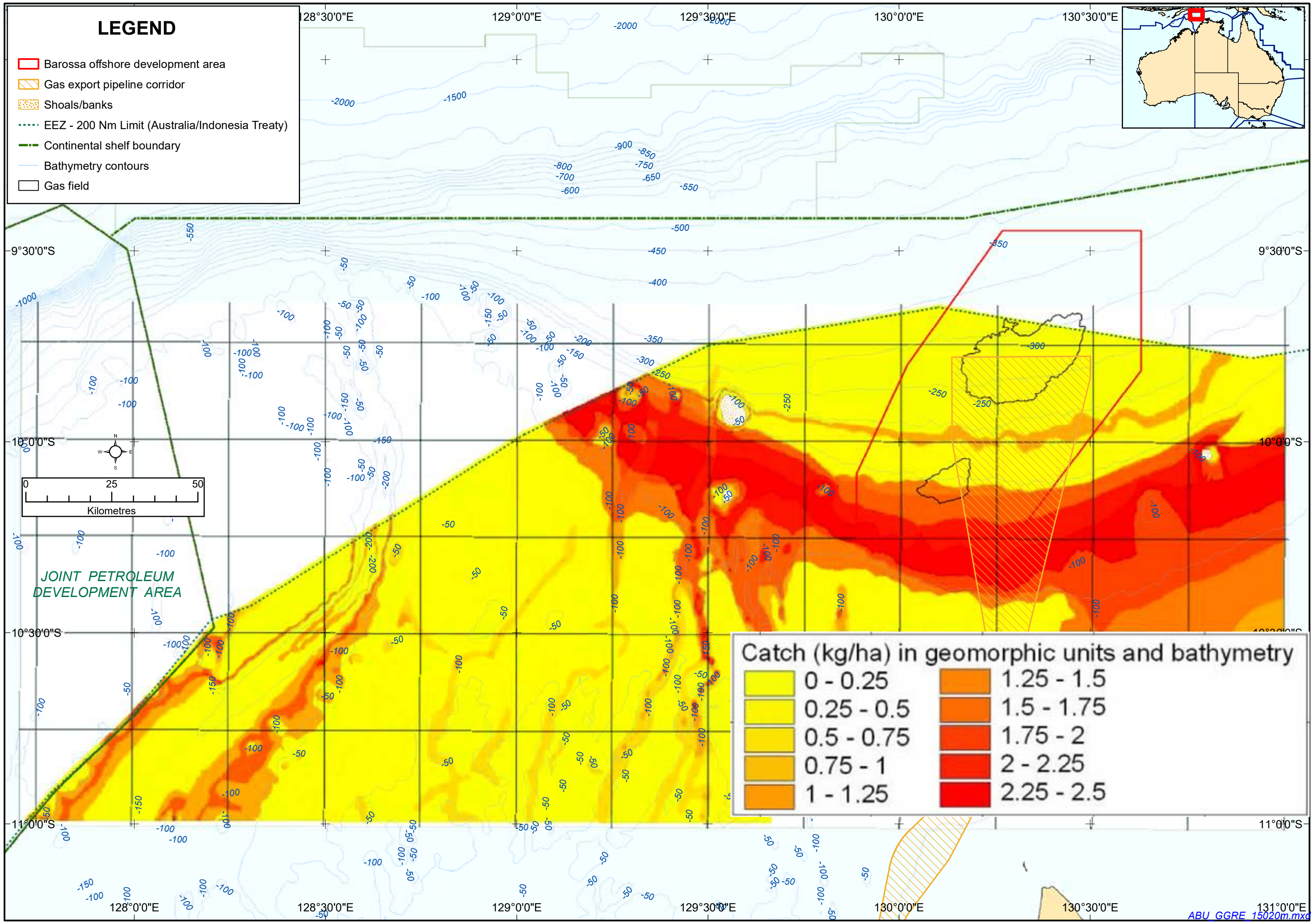


Figure 5-23: NT and WA managed commercial fisheries and NT reef-fish protection areas



(source: DoAWR 2016a)

Figure 5-24: Northern Prawn Fishery relative fishing intensity (2015)



(source: Lloyd and Puig 2009)

Figure 5-25: Commercial productivity of the Timor Reef Fishery (dropline catch only) 1995-2004

5.7.13 Traditional Indigenous fishing

The majority of the project is located in remote offshore waters that are unlikely to be regularly accessed by traditional indigenous fishing activities as almost all Indigenous fishing effort is concentrated within 3 nm of the NT coast (DPIF 2015). However, the southern end of the gas export pipeline corridor in the vicinity of the Tiwi Islands may traverse an area of waters fished by Indigenous people (refer to discussion below). Some encounters with traditional Indonesian fisherman in the general vicinity of the Barossa offshore development area can be expected as they may pass through the area.

In a broader regional context, a traditional Indonesian Fishing area is established approximately 720 km south-west of the Barossa offshore development area, known as the MoU box. Under a MoU signed between Australia and Indonesia in November 1974, an agreement to permit traditional Indonesian fishing practices in the region was formalised (DSEWPaC 2012b). As such, Indonesian and Timorese fishermen are legally permitted to harvest marine products. This MoU box covers Scott Reef and surrounds, Seringapatam Reef, Browse Island, Ashmore Reef, Cartier Island and various banks, representing an area of approximately 50,000 km^2.

Traditional fishing within the areas of the Ashmore Reef and Cartier Island marine parks is permitted. Fishers may access the reefs of Cartier Island and Seringapatam Reef, and visit Ashmore Reef for access to fresh water and to visit graves (DEWHA 2008c).

Trochus, sea cucumbers (holothurians), abalone, green snail, sponges, giant clams and finfish, including sharks, are targeted by the fishers, concentrating on the reefs or in the reef lagoons. While absolute fishing effort is difficult to estimate, in 2006, 100 Indonesian fishing vessels were recorded in the vicinity of Scott Reef (Woodside 2011) and vessels have also been observed during baseline studies undertaken by ConocoPhillips in the vicinity of Seringapatam and Scott Reefs. Peak fishing season is typically between August and October with fishers departing the region at the onset of the northwest monsoon season. Fishing pressure from Indonesian fishers has led to a decline in the target species at Seringapatam Reef and Scott Reef (DEWHA 2008c).

As outlined in **Section 3.6**, Indonesia has rights to pelagic fish stocks in the Perth Treaty area and therefore may access this area for traditional fishing purposes.

Tiwi Islands

A number of different fisheries operate in the vicinity of the Tiwi Islands, which occur in the vicinity of the southern end of the pipeline corridor and within the broader area of influence. However, there appears to be a significant overlap in the harvest of primary species by traditional Indigenous, recreational and commercial fishers (DPIF 2014). For example, fish that are important to both recreational and Indigenous fishers and to the commercial Coastal Line Net Fishery include mullet, catfish, snappers, sharks, threadfins and trevallies (Henry and Lyle 2003, cited in DPIF 2014).

In general, traditional Indigenous fishing effort is greatest near the larger aboriginal communities of Wurrumiyanga on Bathurst Island, and Pirlangimpi and Milikapiti on Melville Island (DPIF 2014). The Tiwi Islanders continue to undertake the customary harvesting of sea turtles and dugongs (Department of Environment and Water Resources 2006). Green turtles appear to be the main species harvested in the water while eggs of all turtle species are taken periodically. Dugongs are also taken occasionally.

The Darwin Aquaculture Centre is working with Tiwi Islander elders to trial the farming of the blacklip oyster, which forms part of the traditional diet for the islanders. The elders are aiming to grow enough blacklip oysters to boost seafood supplies to the community (DPIF 2014). Pilot scale trials are also underway using recent advances in culture methods for sea cucumbers, giant clams and tropical rock oysters (DPIF 2015).

In terms of fishing tour operators, the key target species in the vicinity of the Tiwi Islands has traditionally been barramundi (DPIF 2014).

5.7.14 Tourism and recreational activities

The Barossa offshore development area and majority of the gas export pipeline are located in offshore waters that are not likely to be accessed for tourism activities (recreational fishing and boating and charter boats operations) which tend to be centred on nearshore waters, islands and coastal areas. A number of fishing charters operate in the coastal waters along the NT coastline (within 3 nm) and in the vicinity of the Melville and Bathurst Islands (DPIF 2015). These waters are also used by recreational fishers. Consultation undertaken by ConocoPhillips identified one fishing charter operator who conducts a number of tours in open offshore waters in the vicinity of Evans Shoal and Goodrich Bank during the main fishing season (September to December).

A specimen shell collection enterprise occurs around Ashmore Reef and Cartier Island. Fishing and diving charter companies offer tours to fishing spots off the WA coast, including Seringapatam Reef, and dive spots which include Ashmore Reef, Cartier Island, Hibernia Reef and Seringapatam Reef. These offshore areas are encompassed in the area of influence.

Tourism on the mainland of the Tiwi Islands is focussed on fishing, local arts and crafts, and Indigenous cultural tours.

In summary, there are limited recreational activities observed or expected to occur in the deep water offshore environment of the Barossa offshore development area and the majority of the export pipeline. Nonetheless, some occasional activity may be encountered within the regional marine environment, including within the area of influence.

5.7.15 Mariculture activities

The project area is located in offshore waters that are not accessed for aquaculture activities. Mariculture activities occur in NT coastal waters, which occur in the broader region, and include collection of marine fauna for marine aquariums and specimen shell (e.g. pearl oysters) collection.

5.7.16 Defence activities

The Australian Border Force undertakes civil and maritime surveillance (and enforcement) in Australian offshore maritime waters, which includes the Exclusive Economic Zone. As part of their role, Australian Border Force and Australian Customs monitor illegal foreign fishing activity within the boundaries of the MoU Box (**Section 5.7.13**) and the AFZ, which extends to approximately 200 nm from the mainland.

There are no designated military/defence exercise areas in the immediate vicinity of the project. However, regionally relevant activities include the North Australian Exercise Area (NAXA), a maritime military zone administered by the Department of Defence. The NAXA extends approximately 300 km north and west from just east of Darwin into the Arafura Sea and is used for offshore naval exercises and onshore weapon-firing training (Department of Defence 2015).

Consultation undertaken by ConocoPhillips in 2016 identified that the Department of Defence uses the Exclusive Economic Zone as a submarine exercise area.

5.7.17 Ports and commercial shipping

The closest major commercial port to the project area is Darwin, approximately 300 km south of the project area. The Darwin Port Corporation serves a number of shipping and cargo markets, including cruise and naval vessels, livestock exports, dry bulk ore, offshore oil and gas rig services, and container and general cargo (Darwin Port Corporation 2014).

Darwin Port experienced a record number of approximately 3,178 visits from trading vessels in 2013/14; a significant increase of 418 vessels (15%) from the previous year (Darwin Port Corporation 2014). A large portion of the increase in trading vessels in the past two years (total increase of 107%) within Darwin Harbour is attributable to construction of the INPEX Ichthys project (Darwin Port Corporation 2014).

While the port of Darwin remains the primary active port in the region, there is small-scale port activity to the south and east of the project area, at the Tiwi Islands. Port Melville is located on Melville Island (approximately 122 km north of Darwin) and is situated on the Apsley Strait, immediately south of Barlow Point and the community of Pirlangimpi. The wharf infrastructure at Port Melville was constructed in 2013.

Port Melville provides for the export of woodchips for Tiwi Plantations Corporation, and the shipment of equipment and supplies for other projects. The facility is capable of 24-hour operation, although most operations are undertaken during daylight hours. Most vessels enter and exit the Apsley Strait from its northern entrance. This is except for barges travelling between Darwin and Port Melville, which enter and exit the Apsley Strait from its southern entrance.

Cargo transferred at Port Melville currently includes:

- woodchip exports to overseas destinations – up to 12 vessels per year
- cargo movements between Darwin and Port Melville for on-site operations as required.

Total projected monthly vessel movements (excluding pilot vessels) in 2015 is 23, increasing to 28.5 in 2019, however this is subject to commercial arrangements in support of the plantation export and other future uses.

Figure 5-26 provides the shipping routes within waters of the Timor Sea, and shows the main commercial shipping channel tracking approximately 90 km to the south-west of the Barossa offshore development area (AMSA 2017). Smaller pockets of activity, and the pathways tracking to these pockets, in the Barossa offshore development area correlate with previous ConocoPhillips appraisal activities and the movement of support vessels.

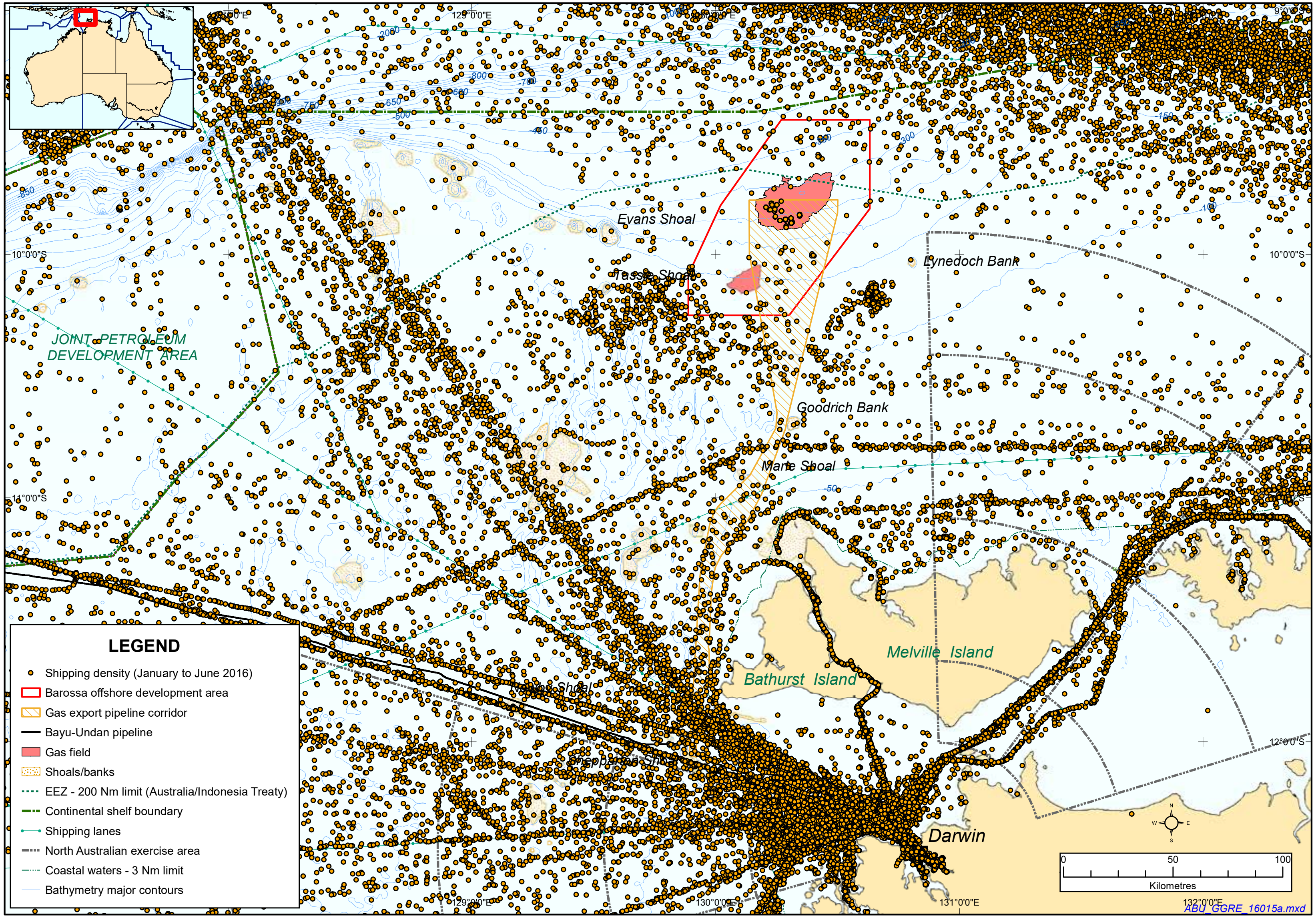


Figure 5-26: Shipping density

5.7.18 Offshore petroleum exploration and operations

There are a number of oil and gas companies holding petroleum permits in the vicinity of project area. However, there are no established oil and gas operations within, or in the immediate surrounds.

The closest operational production facilities and in-field subsea infrastructure are associated with the ConocoPhillips operated Bayu-Undan platform approximately 360 km to the west-south-west. Other subsea infrastructure includes the Bayu-Undan to Darwin gas pipeline and Ichthys gas pipeline to the south-west.

Petroleum retention leases and exploration permit leases within the broader region are currently held by various oil and gas operators (and subsidiaries), including Woodside Energy Ltd, Shell Development (Australia) Pty Ltd, ConocoPhillips STL Pty Ltd, Osaka Gas Australia Pty Ltd, Eni, Magellan, Murphy Oil, Alpha Oil and Natural Gas, Total, Origin Energy, MEO Australia Ltd., Santos, INPEX and PTTEP Australia.

5.7.19 Scientific research

Scientific expeditions and surveys occur on occasion across the broader offshore Timor Sea and Browse Basin, with the majority of these studies undertaken by AIMS, university institutions and WAM. The WA State Government has also published a Kimberley Science and Conservation Strategy (2011) and the North Kimberley Marine Park Joint Management Plan (2016), which has been supported by a number of surveys of the northern Kimberley Islands and coastline.

5.7.20 Indonesian and Timor coastlines

The Barossa offshore development area is located approximately 120 km south of the Indonesia coastline, 530 km east south-east of the West-Timor coastline and 335 km east south-east of the Timor-Leste coastline. While planned project operations are not expected to have any impacts on Indonesian and Timor-Leste waters and shorelines, the area of influence takes into account these values. The coastlines of these countries support a range of habitats and communities, including sand and gravel beaches, rocky shores and cliffs, intertidal mud flats, mangroves, seagrass and coral reefs (Tomascik et al. 1997; Asian Development Bank 2014). The coastal waters provide habitat for a number of protected species, including humphead wrasses, marine turtles, giant clams, some mollusc species, crustaceans, cetaceans (dolphins and whales) and dugongs, and commercially important species of fish, shrimps and shellfish (Asian Development Bank 2014). Nearshore waters also support significant capture fisheries (commercial and subsistence) that contribute to the nation's economy and employment (Asian Development Bank 2014). ConocoPhillips has established communication lines with DFAT with regards to spill response. ConocoPhillips also has offices in Indonesia with a team of local support resources.

5.8 Summary of key environmental, cultural and socio-economic values and sensitivities

Table 5-10 provides a summary of the environmental, cultural and socio-economic features discussed in **Section 5.4** to **Section 5.7**. It identifies the relevant values and sensitivities in the context of both the project area and the area of influence.

Identification of the relevant values and sensitivities assisted in informing the focus of the environmental risk assessment process (as presented in **Section 6**), and were used as the basis for determining the level of detail that is appropriate to the nature and scale of each impact or risk.

In order to refine the basis for relevance of the values and sensitivities presented in **Table 5-10**, it is important to understand the seasonal windows in which key marine fauna (or critical activities such as breeding and migration occur) or socio-economic activities are present. The seasonal presence of the key marine fauna species identified in the EPBC Protected Matters search and cultural and socio-economic values is presented in **Table 5-11** to **Table 5-13**. The data presented in these tables estimating seasonal presence is a summary of the information presented in **Section 5.6** and is based on the publicly available literature outlined in **Section 5.1**.

Table 5-10: Summary of environmental, socio-economic and cultural values and sensitivities and associated relevance to the project

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
Physical environment					
Climate	Not relevant given the nature and scale of the project				Not applicable
Oceanography	Not relevant given the nature and scale of the project				Not applicable
Bathymetry and seabed features	✓	Seabed features	✓	Seabed features	Physical environment (including water, sediment and air quality, background/ambient underwater noise and seabed features)
Water quality	✓	Water quality	✓	Water quality	
Sediment quality	✓	Sediment quality	✓	Sediment quality	
Air quality and meteorology	✓	Air quality			
Underwater noise	✓	Marine mammals Marine reptiles			
Biological environment					
Benthic habitats and communities	✓	Benthic habitats and communities associated with predominantly silty sand, with some hard substrate within the gas export pipeline corridor	✓	May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Physical environment (seabed features)
Shoals, banks, and other regional seabed features of reference			✓	The shoals/banks nearest to the project area include Evans Shoal, Tassie Shoal, Lynedoch Bank, Goodrich Bank, Marie Shoal and Shepparton Shoal. May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Shoals and banks
Offshore reefs and islands			✓	Tiwi Islands Ashmore Reef Cartier Island Hibernia Reef Seringapatam Reef Scott Reef	Tiwi Islands Other offshore reefs and islands and NT/WA mainland coastline

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
NT and WA mainland coastline			✓	May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Other offshore reefs, islands and NT/WA mainland coastline
Plankton	✓		✓		Plankton
Listed threatened and migratory species of conservation significance	✓	20 threatened species and 41 migratory species	✓	27 threatened and 68 migratory species	Marine mammals Marine reptiles Birds Sharks and rays Fish
Cultural and socio-economic environment					
World heritage properties	Not relevant – there are no designated world heritage areas within the project area or area of influence				Not applicable
National heritage places			✓	Ashmore Reef and Cartier Island National Nature Reserve	Other offshore reefs, islands and NT/WA mainland coastline
Commonwealth heritage places			✓	Ashmore Reef Seringapatam Reef Scott Reef	Commonwealth heritage places
Declared Ramsar wetlands			✓	Ashmore Reef	Other offshore reefs, islands and NT/WA mainland coastline
AMPs	✓	Oceanic Shoals (gas export pipeline corridor)	✓	Oceanic Shoals, Arafura, Arnhem, Kimberley, Ashmore Reef, Cartier Island	AMPs
Listed threatened communities	Not relevant – there are no listed threatened communities, as defined under the EPBC Act				Not applicable
Commonwealth marine area	Not relevant – no distinct values or sensitivities associated with this feature which are not captured in other values and sensitivities elsewhere				Not applicable

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
KEFs	✓	Shelf break and slope of the Arafura Shelf (Barossa offshore development area and gas export pipeline corridor) Carbonate bank and terrace system of the Van Diemen Rise (gas export pipeline corridor)	✓	Shelf break and slope of the Arafura Shelf Carbonate bank and terrace system of the Van Diemen Rise Pinnacles of the Bonaparte Basin Tributary canyons of the Arafura depression Carbonate bank and terrace system of the Sahul Shelf Continental slope demersal fish communities Ashmore Reef and Cartier Island and surrounding Commonwealth waters Seringapatam Reef and Commonwealth waters in the Scott Reef complex Ancient coastline at 125 m depth contour	KEFs
Commonwealth land			✓	Ashmore Reef Cartier Island	AMPs
Indigenous heritage			✓	Tiwi Islands Ashmore Reef May be affected under the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Tiwi Islands Other offshore reefs and islands and NT/WA mainland coastline
Marine archaeology			✓	Three historic shipwrecks – two steamer ships sunk to the north-west and adjacent to the west coast of Bathurst Island and a submarine sunk in the Beagle Gulf	Marine archaeology
Commercial fisheries	✓	Commonwealth: Northern Prawn Fishery, Southern Bluefin Tuna Fishery, Western Skipjack Tuna Fishery, Western Tuna and Billfish Fishery NT: Aquarium Fishery, Coastal Line Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery, Timor Reef Fishery	✓	Commonwealth: Northern Prawn Fishery, NWSTF, Southern Bluefin Tuna Fishery, Western Skipjack Tuna Fishery, Western Tuna and Billfish Fishery NT: Aquarium Fishery, Coastal Line Fishery, Demersal Fishery, Offshore Net and Line Fishery, Spanish Mackerel Fishery, Timor Reef Fishery WA: Mackerel Managed Fishery, NDSF, Northern Shark Fisheries	Commercial fishing

Value/sensitivity	Present in the project area	Particular values/sensitivities of relevance	Present in the area of influence	Particular values/sensitivities of relevance	Factor grouping in the risk-based impact assessment (Table 6-7)
Traditional Indigenous fishing	✓	Tiwi Islands (in the vicinity of the southern end of the gas export pipeline corridor)	✓	MoU box	Recreational and traditional fishing
Tourism and recreational activities	✓	Tiwi Islands (in the vicinity of the southern end of the gas export pipeline corridor)	✓	Evans Shoal Goodrich Bank Ashmore Reef Cartier Island Hibernia Reef Seringapatam Reef Scott Reef	Tourism, recreation and scientific research
Scientific research	✓	Scientific expeditions and surveys occur on occasion across the broader offshore Timor Sea	✓	Scientific expeditions and surveys occur on occasion across the broader offshore Timor Sea and Browse Basin	
Mariculture activities			✓	Collection of marine fauna for marine aquariums and specimen shell (e.g. pearl oysters) collection	Commercial fishing Recreational and traditional fishing
Defence activities			✓	NAXA	Defence activities
Ports and commercial shipping	✓	Commercial shipping	✓	Commercial shipping	Commercial shipping
Offshore petroleum exploration and operations			✓	The closest operational production facilities – the ConocoPhillips Bayu-Undan platform – is approximately 360 km to the west-south-west of the Barossa offshore development area	Offshore petroleum exploration and operations
Indonesian and Timor shorelines			✓	May be affected by the potential scenario of an unplanned discharge (as discussed in **Section 6.4.10**).	Other offshore reefs, islands and NT/WA mainland coastline

Table 5-11: Seasonal presence of key marine fauna predominantly relevant to the Barossa offshore development area

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Pygmy blue whale – migration												
Bryde's whale – presence												
Humpback whale – migration and breeding[1]												
Sei whale[2]												
Fin whale[2]												
Omura's whales – presence												
Antarctic minke whale[1, 2]												
Killer whale[1, 2]												
Sperm whale[1, 2]												
Flatback turtle (Arafura genetic stock) – presence												
Green turtle (Cobourg Peninsula genetic stock) – presence												
Olive ridley (NT genetic stock) – presence												
Loggerhead turtles – presence												
Leatherback turtles – presence												
Hawksbill turtles – presence												
Sea snakes – presence												
Seabirds – feeding, aggregation, breeding												
Migratory shorebirds – aggregation, breeding												
Migratory seabird – streaked shearwater												

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Migratory seabird – fork-tailed swift – presence (note, species is almost exclusively aerial when over Australian waters)												
Migratory wetland – curlew sandpiper – presence												
Migratory wetland – eastern curlew – presence												
Migratory seabird – common noddy – presence												
Migratory seabird – greater frigatebird- breeding												
Migratory seabird – lesser frigatebird – breeding												
Whale shark[1]												
Great white shark[1, 2]												
Grey nurse shark												

Key

	Species likely to be present in the region
	Peak presence/occurrence (presence of animals reliable and predictable each year) or increased activity

[1] Relevant predominantly to the area of influence.

[2] The movements and distributions of the species are not well documented and it has therefore been assumed, as a conservative approach, that they may be present year-round.

Table 5-12: Seasonal presence of key marine fauna predominantly relevant to the gas export pipeline corridor

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Flatback turtle (Arafura genetic stock) – nesting												
Flatback turtle (Arafura genetic stock – internesting												
Green turtle (Cobourg Peninsula genetic stock) – nesting												
Green turtle (Cobourg Peninsula genetic stock) – internesting												
Olive ridley (NT genetic stock) – nesting												
Olive ridley (NT genetic stock) – internesting												
Loggerhead turtles – presence												
Leatherback turtles – nesting												
Hawksbill turtles – presence												
Seabirds – feeding, aggregation, breeding												
Migratory shorebirds – aggregation, breeding												
Migratory seabird – crested tern – breeding on Tiwi Islands												
Migratory seabird – streaked shearwater												
Migratory seabird – fork-tailed swift – presence (note, species is almost exclusively aerial when over Australian waters)												
Migratory wetland – curlew sandpiper – presence												
Migratory wetland – eastern curlew – presence												
Migratory seabird – common noddy – presence												
Migratory seabird – greater frigatebird- breeding												
Migratory seabird – lesser frigatebird – breeding												
Migratory wetland – osprey – presence												
Migratory wetland – red knot – presence												
Migratory wetland – sharp-tailed sandpiper – presence												
Migratory wetland – pectoral sandpiper – presence												
Migratory wetland – common sandpiper – presence												
Dugong – presence (Tiwi Islands)												
Spotted bottlenose dolphin (Arafura/Timor Sea populations) – foraging, feeding and breeding												
Indo-pacific humpback dolphin – presence												

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Australian snubfin dolphin – breeding, calving												
Sea snakes – presence												
Shortfin mako – presence												
Longfin mako – presence												
Speartooth shark – pupping												
Northern river shark – pupping												
Green sawfish, largetooth sawfish, dwarf sawfish, narrow sawfish – pupping												
Reef manta ray												
Giant manta ray												
Whale shark												
Great white shark[1]												
Grey nurse shark[2]												

Key

	Species likely to be present in the region
	Peak presence/occurrence (presence of animals reliable and predictable each year)

[1] The movements and distributions of the species are not well documented and it has therefore been assumed, as a conservative approach, that they may be present year-round.

[2] Relevant predominantly to the area of influence.

Table 5-13: Seasonal presence of key cultural and socio-economic values in the project area

Environmental value/sensitivity	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Northern Prawn Fishery (Cwlth)				▒	▒	▒		▒	▒	▒	▒	
NWSTF (Cwlth)	▒	▒	▒	▒		▒	▒					▒
Southern Bluefin Tuna Fishery (Cwlth)[1]												
Western Skipjack Tuna Fishery (Cwlth)[1]												
Western Tuna and Billfish Fishery (Cwlth)[1]												
Aquarium Fishery (NT) – Evans Shoal and Lynedoch Bank	▒	▒	▒	▒	▒				▒	▒	▒	▒
Coastal Line Fishery (NT)	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Demersal Fishery (NT)	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Offshore Net and Line Fishery (NT)	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Spanish Mackerel Fishery (NT)	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Timor Reef Fishery (NT)	█	█	█	█	█	▒	▒	▒	▒	█	█	█
Mackerel Managed Fishery (WA)	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
NDSF (WA)	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Northern Shark Fisheries (WA) [1]												
Fishing charters – Evans Shoal and Goodrich Bank									▒	▒	▒	▒
Indigenous fishing	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒

Key	
▒	Activity likely to be present in the region
█	Peak/increased activity

[1] While the project overlaps the project area, the fisheries are highly unlikely to operate in the area or have been inactive for several years.

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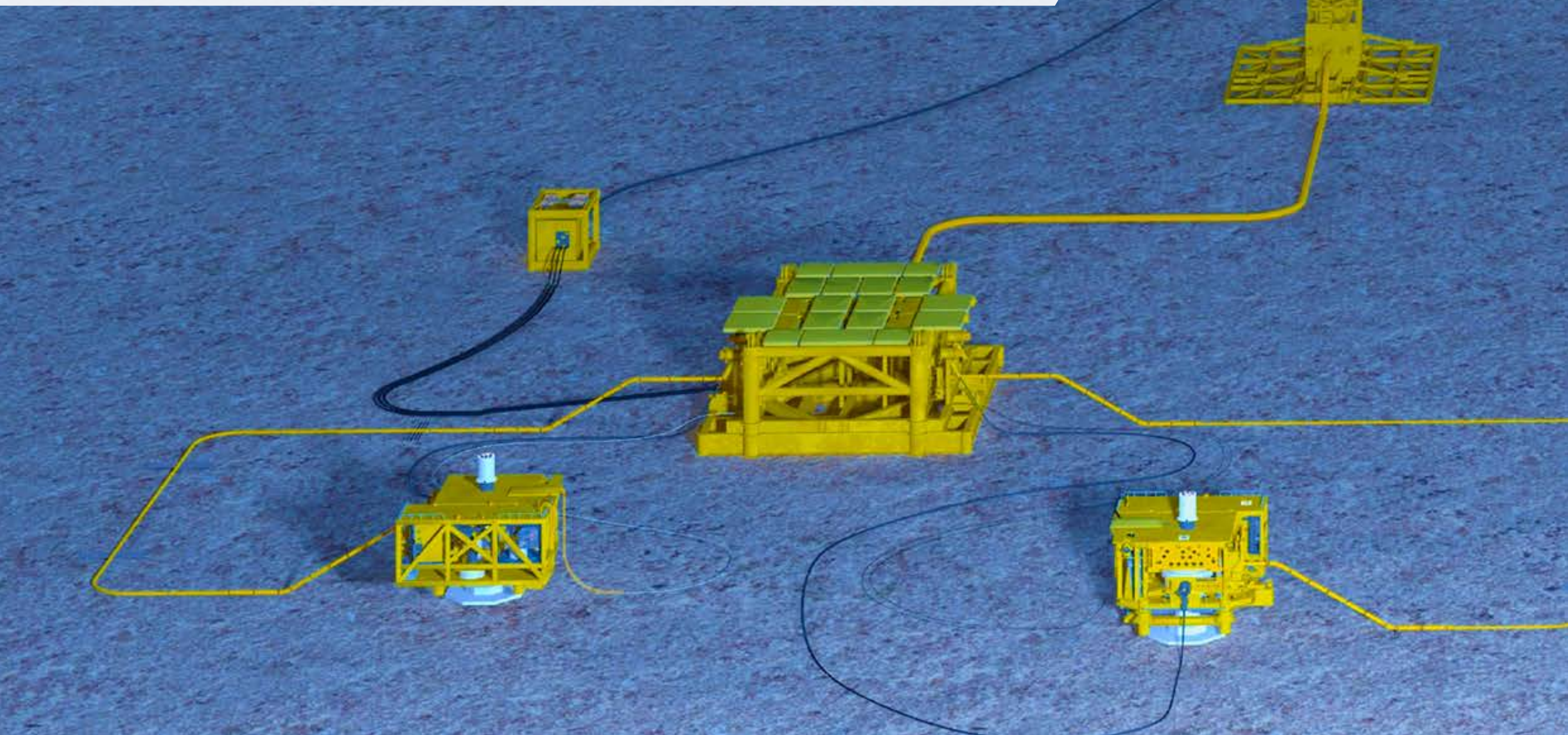
6 Evaluation of environmental impacts and risks



Section 6 summary

Purpose:

This section explains how all environmental impacts and risks have been evaluated and how they will be managed to an acceptable level, including the key management controls that will be applied. For NOPSEMA to consider a project "acceptable", ConocoPhillips must demonstrate it has considered all relevant regulations and guidelines, ecologically sustainable development principles, ConocoPhillips' own policy and standards, and the potential environmental consequences and community expectations.

Section at a glance:

NOPSEMA's Guidance Note provides important context to this section by explaining the level of detail required, the types of process that should be followed, and the main terminology used.

The risk assessment uses a precautionary approach in terms of defining the 'outer boundary' within which the environment could be affected by the project, i.e. the area of influence. The assessment process considers two forms of impacts and risks - those associated with planned events, such as atmospheric emissions and discharges to sea during normal operations (including cumulative impacts), and those associated with highly unlikely unplanned events, such as hydrocarbon release caused by vessel collisions or a loss of well control.

As the OPP occurs in the early design phase of a project, a description of key control measures is provided at a high-level and management systems that can be used to reduce the environmental impacts and risks of the project to an acceptable level, is provided. Further, procedural controls will be further detailed in the subsequent EPs for each activity, to ensure risks are as low as reasonably practicable. The likelihood, potential magnitude and duration, and consequences of project activities is considered along with the control measures (systems, equipment, people, procedures) used to manage them.

Following the risk assessment process, and informed by ConocoPhillips' understanding and experience, most environmental risks were considered to be low. Some impacts and risks are unavoidable, like the physical presence of facilities or planned discharges and emissions. However, these impacts and risks are low given the open ocean location and the distance from key features, such as shoals and banks, and can be managed and controlled with good industry practice.

Overall, potential impacts and risks to marine fauna and habitat from planned activities will be at a local level, as opposed to a regional level, affecting individuals rather than populations. No facilities in the Barossa offshore development area will be placed near any areas of regional environmental importance such as shoals, banks and coral reefs.

The southern end of the gas export pipeline corridor is closer to more sensitive environmental features, but the impacts and risks are considered to be low due to activity in this area primarily associated with the initial pipeline installation and there are no ongoing discharges along the pipeline compared to operations in the offshore development area. To inform the impact and risk assessment of unplanned activities, comprehensive modelling of potential hydrocarbon releases to the marine environment is illustrated, with an evaluation of worst-case scenarios where the outer boundary of all credible spill trajectories is considered, however unlikely they may be. This approach ensures the impact and risk assessment accounts for different seasonal and environmental conditions that could occur at the time of a vessel collision or loss of well control, including wind, wave and climate conditions. The impact assessment is also based on spill modelling where no response measures were taken, compared to a true scenario where all appropriate response measures are taken.

ConocoPhillips has safely drilled a number of appraisal wells in the Bonaparte and Browse Basins over many years and has also safely operated processing and offtake facilities at Bayu-Undan in the Timor Sea for the past 12 years including the safe transfer of hydrocarbons to tankers offshore. ConocoPhillips will apply the same approach to identify and implement the key controls required to manage the potential impacts and risks associated with the project.

6 Evaluation of environmental impacts and risks

6.1 Introduction

This OPP provides an evaluation of environmental impacts and risks for the project at the early design phase, to enable NOPSEMA to give early consideration of the acceptability of the development on a 'whole of life-cycle' basis.

The evaluation of the environmental impacts and risks has been informed by a comprehensive risk assessment process, taking into account the nature and scale of each potential impact, the likelihood of the impact occurring and its acceptability in the context of the existing environment (as previously described in **Section 5**).

The holistic risk assessment process detailed in this section encompasses an evaluation process for all the potential impacts that may arise directly or indirectly from all future activities, both planned and unplanned. ConocoPhillips is committed to an ongoing risk assessment process, with potential impacts and risks to be reviewed and further assessed in activity-specific EPs.

The purpose of this section aligns with the NOPSEMA OPP Guidance Note (NOPSEMA 2016a):

- *"To detail and evaluate the environmental impacts and risks including their sources, potential events, likelihood and consequences and also estimate the magnitude of impacts and risks."*
- *"To demonstrate that the project can be undertaken in such a way that the environmental impacts and risks will be managed to an acceptable level."*

To demonstrate the close inter-linkages between the assessment of environmental impacts and risks, and evaluation of acceptability at a 'whole-of-project' level, **Figure 6-1** is presented to provide an overview of the process undertaken for this OPP.

To ensure a fully integrated view of the environmental acceptability assessment, the reader is encouraged to read this section in conjunction with **Section 7** (Environmental Performance Framework).

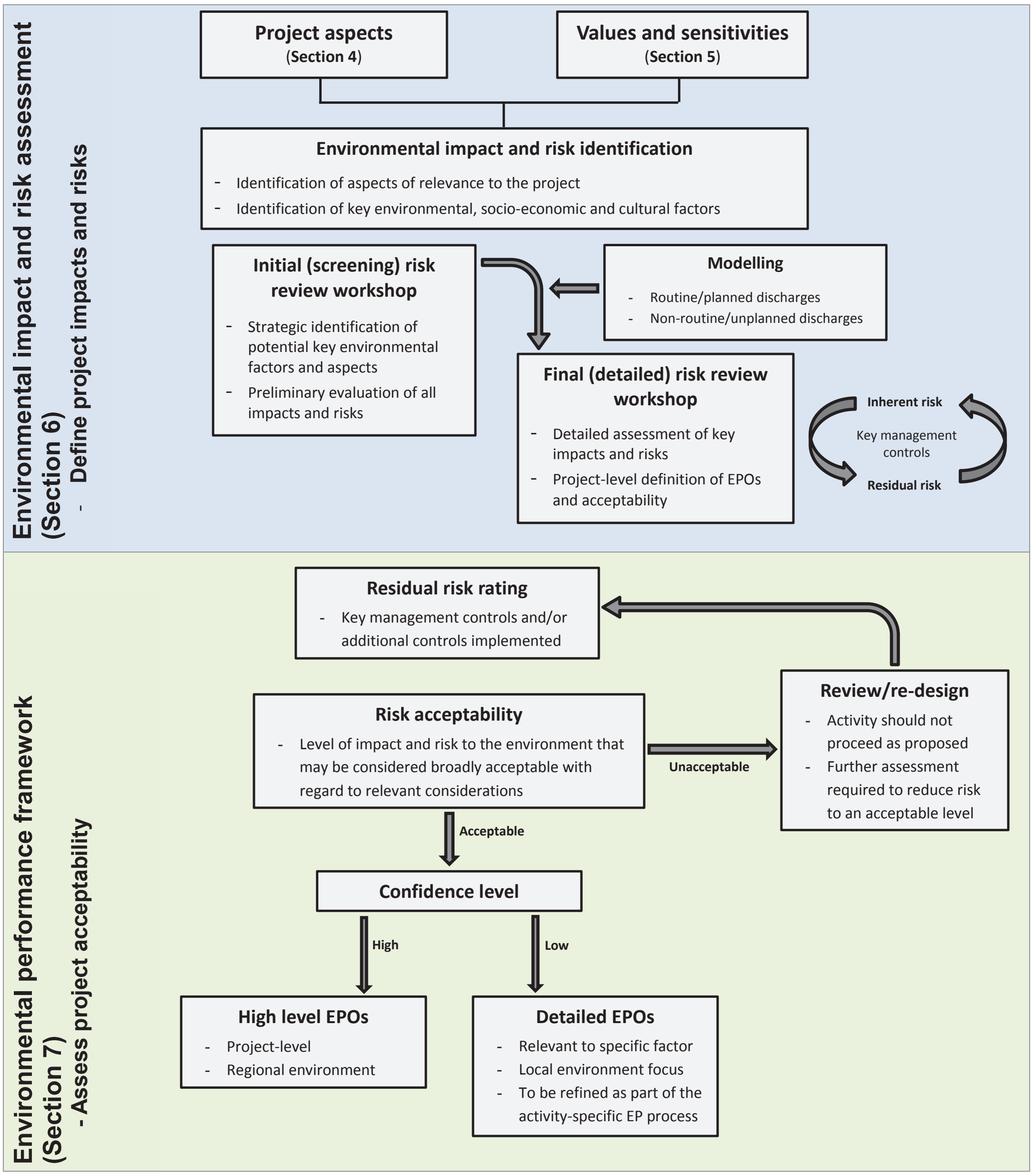


Figure 6-1: Summary overview of the evaluation of risks, impacts and project acceptability

6.2 Environmental risk assessment process

6.2.1 Overview

This OPP demonstrates risk assessment and risk mitigation, and provides discussion of various control measures at a high-level and management systems that can be used to reduce the environmental impacts and risks of the project to an acceptable level. The OPP approach applies a robust risk assessment process, based on the principles of Australian Standard/New Zealand Standard International Organisation for Standardisation (AS/NZS ISO) 31000:2009 and ConocoPhillips' risk assessment process (**Figure 6-2**), that has been applied consistently to address all key elements of the concept project description.

ConocoPhillips considers the key steps of risk management to include:

- establishing the context with regard to relevant ConocoPhillips management systems (**Section 2**), legislation/guidance (**Section 3**), existing environment (**Section 5**) and relevant stakeholder context (**Section 8**)
- identification of hazards/risks associated with a system and/or process and definition of the credible risk source scenarios, with consideration of ConocoPhillips' operational experience, the existing environment and relevant stakeholder context
- identification of the existing hazard/risk control measures in place
- assessment of the risk with existing control measures in place to determine the inherent risk
- identification and consideration of potential additional control measures to reduce the risk to ALARP and acceptable level
- assessment of risk with any additional control measures in place to determine the residual risk and evaluate if the risk has been reduced to ALARP and is acceptable
- application of further additional controls if needed.

In accordance with the NOPSEMA OPP Guidance Note (NOPSEMA 2016a), the OPP "*must include an evaluation of all the impacts and risks that reaches a conclusion on whether the impacts and risks will be 'acceptable' or 'unacceptable'*". The demonstration of ALARP is an evaluation criteria relevant to subsequent activity-specific EPs, but is not considered further when evaluating impacts and risks for the purposes of this OPP. At the time of preparing the OPP, project design and execution detail is high level and preliminary, and not sufficiently detailed to perform an ALARP assessment. A much greater level of detail regarding project design and execution will be known during development of activity-specific EPs, at which time an ALARP assessment will be performed.

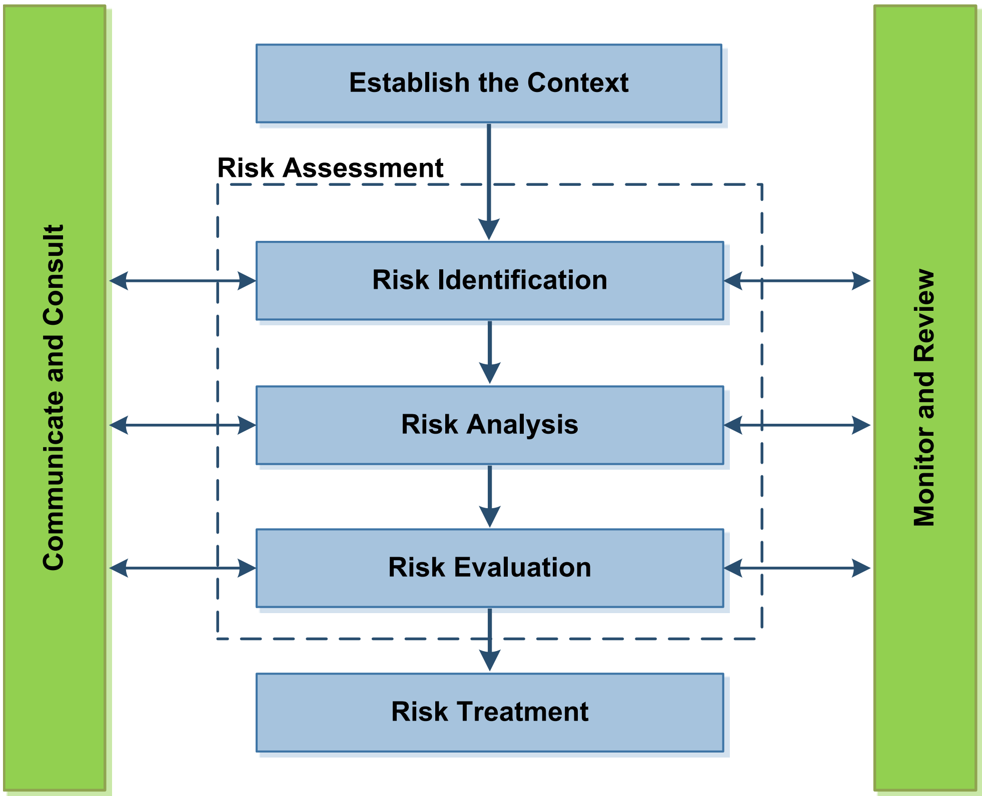


Figure 6-2: Environmental risk assessment process

In the context of the project OPP, the risk assessment process provides:

- an account of ConocoPhillips' processes to evaluate all potential risks to environmental, socio-economic and cultural values arising from activities associated with the project throughout its life-cycle
- the range of control measures, as able to be identified at this early stage of the project, for mitigating those potential risks to demonstrate that the project can be undertaken in such a way that its environmental impacts and risks will be managed to an acceptable level.

The environmental risk assessment process includes consideration of various elements that are documented throughout the OPP. These elements are detailed in the following sections:

- establishing the context – relevant legislation/guidance (**Section 3**), ConocoPhillips management systems (**Section 2**), and understanding the values and sensitivities of the existing environment (**Section 5**)
- risk identification – identification of project activities and relevant aspects (**Section 4**), and which activities may result in a material impact (**Section 6**)
- risk analysis – quantification of the risk level associated with the impact (**Section 6**)
- risk evaluation – evaluation of the risks in the context of acceptability (**Section 6**)
- risk treatment – identification of high level control measures (**Section 6**) and relevant EPOs (**Section 7**).

Table 6-1 provides definitions for the environmental risk assessment terms used in this OPP.

Table 6-1: Risk assessment terminology and definitions

Term	Definition
Activity	Components or elements of work associated with the project. All activities associated with the project have been considered at a broad level (as outlined in **Section 4**).
Aspect	Elements of the proponent's activities or products or services that can interact with the environment. These include planned and unplanned (including those associated with emergency conditions) activities.
Factor	Relevant natural, socio-economic and cultural features of the environment. These are also referred to within the OPP as values/sensitivities.
Potential impact	Any change to the environment, whether adverse or beneficial, wholly or partially resulting from a proponent's environmental aspects.
Event	An occurrence of a particular set of circumstances. An event can be one or more occurrences and can have several causes.
Hazard	A substance, situation, process or activity that has the ability to cause harm to the environment.
Control	A measure which mitigates risk through the reduction of the likelihood for a consequence to occur. Controls include existing controls (i.e. ConocoPhillips' management controls or industry standards) or additional controls (i.e. additional measures identified during the risk assessment processes).
Consequence	The outcome of an event, which can lead to a range of consequences. A consequence can be certain or uncertain and can have positive or negative effects. Consequences can be expressed qualitatively or quantitatively. For risk assessment purposes, the consequence typically remains unchanged since it is determined without controls in place.
Likelihood	Description of probability or frequency of a consequence occurring with safeguards in place.
Inherent risk	The level of risk when existing controls are in place, but before the application of additional risk controls arising from risk assessment processes.
Residual risk	The level of risk remaining after risk treatment, i.e. application of additional controls (inclusive of unidentified risk).
Acceptable	The level of impact and risk to the environment that may be considered broadly acceptable with regard to all relevant considerations. Refer to **Section 6.2.4** for further discussion on the definition of acceptability.

6.2.2 Establish the context and risk identification

6.2.2.1 Identification of aspects of the project of relevance to the risk assessment

A review of the potential activities comprising the project was undertaken in order to identify those activities, in the context of the project location, that could lead to potential impacts on the existing environment. In risk terminology, aspects are defined as elements (or activities) of a proposal that interact with or present a risk to an environmental factor (also referred to as values/sensitivities), for example, the physical presence of the development infrastructure. The aspects relevant to the project are described previously in **Section 4.3.5**.

Each of the aspects have been considered in terms of the potential to interact with environmental, socio-economic and cultural factors, as discussed below.

6.2.2.2 Identification of factors of relevance to the risk assessment

In the context of the risk assessment process, an environmental factor is defined as the part of the existing environment that may be affected by an aspect of the project, for example, marine mammals. A process to identify environmental, socio-economic and cultural factors, and the potential interactions between them, has drawn on a broad range of information sources, including:

- a review of the DoEE Protected Matters database (**Section 5.5.1** and **Appendix P**)
- a review of the DoEE National Conservation Values Atlas (**Section 5.6.1**)
- information obtained through stakeholder engagement
- the Barossa marine studies program (**Section 5.2**) undertaken to provide information on environmental factors
- collation of knowledge developed by ConocoPhillips during prior assessment and successful operation of full field LNG developments, and review of experience from multiple seismic and drilling campaigns in the Barossa permit areas.

The factors relevant to the project and key factors of primary relevance to the project area (i.e. the Barossa offshore development and gas export pipeline corridor) have been distinguished.

In this way, the environmental, socio-economic and cultural factors that could be influenced were identified, as described in **Section 5**. These included:

- physical environment – seabed features, marine water quality, marine sediment quality, air quality and underwater noise
- ecological – benthic habitats and communities (e.g. infauna, seagrass, macroalgae, corals), shoals/banks, offshore reefs and islands, NT/WA mainland coastline, marine mammals, marine reptiles (turtles and sea snakes), birds (seabirds and migratory shorebirds), fish, sharks and rays, plankton, BIAs for marine fauna and internesting habitat critical to the survival of marine turtles
- socio-economic and cultural – Commonwealth and National Heritage places, Ramsar wetlands, KEFs, Commonwealth marine areas, AMPs, marine archaeology, commercial fishing, traditional and recreational fishing, tourism, recreation and scientific research, commercial shipping, other offshore petroleum exploration and operations, and defence activities.

6.2.2.3 Key environmental, socio-economic and cultural values and sensitivities identified for the project

The key values and sensitivities of primary relevance to the project are outlined in **Table 6-2** below, and grouped according to their similarities. These have been identified based on a detailed understanding of the existing environment, as discussed in **Section 5**. MNES as defined under the EPBC Act are given explicit consideration in the assessment of potential environmental impacts and risks of the project.

Table 6-2: Key values/sensitivities of primary relevance to the project

Key value/sensitivity	Rationale
• Evans Shoal • Tassie Shoal • Lynedoch Bank • Goodrich Bank • Marie Shoal • Shepparton Shoal	These represent the nearest shoals/banks to the project area.
• Tiwi Islands	Represents the nearest island to the project area.
• Pygmy blue whales • Bryde's whales • Omura's whales • Sei whales • Fin whales • Humpback whales • Antarctic minke whales • Killer whales • Sperm whales • Dugongs • Dolphins	These species are listed under the EPBC Act and potentially occur or have habitat in the project area and area of influence (**Section 5.6.2**).
• Flatback turtles • Olive ridley turtles • Green turtles • Loggerhead turtles • Leatherback turtles • Hawksbill turtles • Sea snakes	These species are listed under the EPBC Act and are known to occur in the project area (**Section 5.6.3**). Flatback and olive ridley turtles are particularly relevant as the gas export pipeline corridor passes through a portion of the internesting BIA for flatback turtles, is adjacent to the internesting BIA for olive ridley turtles and passes through internesting habitat critical to the survival of both these species (**Figure 5-18**).
• Migratory seabirds • Migratory shorebirds • Crested tern	These species are listed under the EPBC Act and potentially occur or have habitat in the project area (**Section 5.6.4**). The crested tern is of relevance as a small portion of the gas export pipeline corridor passes through a biologically important breeding/foraging area for the species (**Figure 5-19**).
• Whale shark • Offshore pelagic and demersal fish communities • Demersal fishery species	The whale shark is listed under the EPBC Act and potentially occurs, or has habitat, in the project area (**Section 5.6.5.2**). Pelagic and demersal fish communities are of relevance for their socio-economic importance.

Key value/sensitivity	Rationale
• Grey nurse shark • Great white shark • Shortfin mako and the longfin mako • River sharks – northern river shark and speartooth shark (nearshore habitats near Tiwi Islands) • Sawfish – green sawfish, largetooth sawfish and dwarf sawfish (nearshore habitats near Tiwi Islands) • Rays – reef manta ray and giant manta ray (nearshore habitats near the Tiwi Islands)	These species are listed under the EPBC Act and potentially occur or have habitat in the project area (**Section 5.6.6.2**). The grey nurse shark was observed at a seamount during the Barossa marine studies program within the broader surrounds of the Barossa offshore development area (**Section 5.5.5**).
• Oceanic Shoals marine park	A portion of the gas export pipeline corridor area (approximately 708 km²) overlaps the Oceanic Shoals marine park (71,743 km²) (**Figure 5-20**). While the broad corridor overlaps with approximately 1% of the marine park, the area of direct disturbance from the linear pipeline is estimated to only represent approximately 0.0002% of the marine park. Geophysical, bathymetric and environmental baseline surveys have not observed any unique benthic habitats or assemblages in the portion of the pipeline corridor that overlaps with the marine park.
• Shelf break and slope of the Arafura Shelf	A portion of the project (approximately 3,384 km² of the Barossa offshore development area and 2,087 km² of the gas export pipeline corridor) occurs within the shelf break and slope of the Arafura Shelf (10,844 km²) (**Figure 5-20**). The Barossa offshore development area and gas export pipeline corridor overlap approximately 37% of this KEF. However, the direct area of disturbance to this KEF is expected to only represent approximately < 0.007% of this KEF. Geophysical, bathymetric and environmental baseline surveys within the Barossa offshore development area have not identified any seafloor features/values associated with this KEF.
• Carbonate bank and terrace system of the Van Diemen Rise	A portion of the gas export pipeline corridor (approximately 356 km²) overlaps the carbonate bank and terrace system of the Van Diemen Rise (31,278 km²) (**Figure 5-20**). While the broad corridor overlaps with approximately 1% of this KEF, the area of direct disturbance to this KEF from the linear pipeline is expected to only represent approximately < 0.0002% of this KEF. The pipeline corridor has been refined based on geophysical and bathymetric survey data and engineering studies to minimise, as much as practicable, areas of seabed within the pipeline corridor that are associated with the seafloor features/values associated with this KEF.
• Commercial Commonwealth and NT managed fisheries, particularly the Timor Reef Fishery	The project area intersects a number of commercial fisheries. The Timor Reef Fishery is of most relevance as it overlaps the project area (approximately 3,735 km² of the Barossa offshore development area and 2,242 km² of the gas export pipeline corridor), although most recent active fishing effort is to the south-west of the fishery. Fishing is known to occur in the broader surrounds of the project area, including within the area of influence.

6.2.3 Risk analysis and evaluation

The environmental risk review process is a qualitative risk-screening tool for evaluating the potential environmental impacts and risks determined to be relevant to the concept project description outlined in **Section 4**. Risks are rated or ranked by identifying the consequence of each risk and then selecting the likelihood of each consequence occurring. ConocoPhillips assesses the risk in two key stages:

- *inherent risk*: assessment of the potential environmental, socio-economic and cultural consequences and the likelihood of that consequence occurring with the application of existing control measures (e.g. relevant legislation, ConocoPhillips and contractor procedures/standards etc.) for each credible risk source scenario
- *residual risk*: reassessment of the inherent risk following the application of additional controls/ mitigation measures. The number and type of controls/mitigation measures are linked to an acceptable environmental outcome determination and the residual risk equates to the level of acceptable environmental impact expected throughout the project life-cycle.

Two key considerations underpin the environmental risk assessment:

- the severity of the impact in the event that consequence does occur
- the likelihood of factors at risk being affected.

Risk analysis frames the assessment of controls that could be applied during execution of project activities that pose a potential hazard to relevant factors. It also provides a framework to identify the measures to mitigate the severity of the impact arising from either planned or unplanned events. The process provides essential input into the assessment of controls and mitigation measures to ensure that the level of risk posed by a particular aspect is acceptable. Subsequent activity-specific EPs will consider and assess both acceptability and ALARP criteria, in accordance with the OPGGS (E) Regulations and guidance.

The environmental risk assessment method is based on the ConocoPhillips Risk Matrix. This process reflects the risk management process detailed within the AS/NZS ISO 31000:2009 Risk management – Principles and guidelines (Standard) (AS/NZS 2009) and Handbook 203:2006 Environmental risk management – Principles and process (Guide) (AS/NZS 2006).

The level of risk is determined by first establishing the maximum credible consequence of an impact on an environmental, socio-economic or cultural factor resulting from an aspect of the project. Following the determination of the level of consequence, the likelihood of the consequence occurring is then assigned. The assigned consequence and likelihood is mapped on the risk matrix to determine the level of risk, as illustrated on **Table 6-3**.

Refer to **Section 6.3** for a detailed discussion of the environmental risk assessment workshops undertaken to identify and assess risks associated with the project.

Table 6-3: ConocoPhillips risk level matrix

Risk matrix

	Consequence				
Likelihood	Negligible (1)	Minor (2)	Moderate (3)	Significant (4)	Major (5)
Frequent (5)	5	10	15	20	25
Probable (4)	4	8	12	16	20
Rare (3)	3	6	9	12	15
Remote (2)	2	4	6	8	10
Improbable (1)	1	2	3	4	5

Risk rating

Risk score	Risk rating	Description of risk level
IV (17-25)	High	High risk. Manage risk utilising prevention and/or mitigation with highest priority. Promote issue to appropriate management level with commensurate risk assessment details.
III (12-16)	Significant	Significant risk. Manage risk utilising prevention and/ or mitigation with priority. Promote issue to appropriate management level with commensurate risk assessment detail.
II (5-10)	Medium	Moderate risk with controls verified. No mitigation required where controls can be verified as functional. ALARP should be evaluated, as necessary.
I (1-4)	Low	Low risk. Mitigation controls implemented as required.

6.2.3.1 Assessment of consequence of potential impacts

In evaluating the level of consequence of a potential event, the following considerations are applied:

- extent of impacts – whether the impact affects the local or wider regional environment
- frequency and duration of the impact – how often the impact will occur and how long it will interact with the existing environment
- sensitivity of the existing environment (including seasonal values/sensitivities) – nature, importance (local, national or international significance) and the sensitivity or resilience to change of the factor that could be affected. This also considers any relevant laws, regulations or guidelines aimed at protecting the existing environment, including the OPGGS Act (and supporting regulations), the EPBC Act, and relevant recovery plans/management plans and conservation advices.

Environmental, socio-economic, cultural and business consequences can be defined either qualitatively or quantitatively. Where consequences of differing severity were identified for an aspect, the more severe/ higher consequence was selected.

In order to address the potential extent of possible impacts prior to finalising a design option, a conservative approach was taken to defining the 'outer envelope' of impacts associated with the project. The potential impacts were considered in the context of the aspect and factor interaction matrix in **Table 6-7**. The interaction matrix was informed by detailed consideration of the nature and scale of the key project stages (**Section 4**), comprehensive understanding of the existing environment (**Section 5**), including the professional views of recognised experts in specific disciplines areas, and detailed modelling (e.g. key planned and unplanned discharges and underwater noise).

The consequence definitions in the ConocoPhillips Risk Matrix were applied to this risk assessment, as shown in **Table 6-4**. The consequence rating is based on a consequence with no safeguards in place, whereas likelihood is assessed with consideration for existing/standard safeguards. While the risk assessment process was undertaken with a primarily environmental focus, other potential socio-cultural, economic and business impacts were also considered in determining the consequence rating when it was deemed that these other impacts were more significant. Using a conservative approach, the consequence that resulted in the highest risk consequence rating by these definitions was carried through for each potential impact.

Table 6-4: Risk assessment consequence definitions

Consequence severity description			
Rating	**Biodiversity (Bio)**	**Socio-cultural and economic (Soc)**	**Business impact (Bus)**
5 Major	Catastrophic permanent loss/ extinction (100%) of species, habitat or ecosystem. Irrevocable loss, no mitigation possible.	Permanent lost access or use of area with permanent reduction in community or tribal quality of life; major economic impact to surrounding community; irrevocable loss of culture resources. and/or The remediation associated with the environmental harm, asset damage and/or litigation/resolution costs will probably exceed $10 million.	Complete area evacuation. and/or National negative media exposure and/or Business interruption costs likely to exceed $10 million.
4 Significant	Serious loss or migration (> 50%) of species population, habitat or ecosystem. Partial mitigation only possible through prolonged and resource intensive effort (greater than 50 years).	Permanent partial restriction on access or use, or total restriction > 10 years in duration; temporary reduction in quality of life > 10 years duration; harm to cultural resources requiring major mitigation. and/or The remediation associated with the environmental harm, asset damage and/or litigation/resolution costs are between $1 million and $10 million.	Selected areas require evacuation. and/or Regional Asia-pacific negative media exposure and/or Business interruption costs likely to be between $1 million and $10 million.

Consequence severity description			
Rating	**Biodiversity (Bio)**	**Socio-cultural and economic (Soc)**	**Business impact (Bus)**
3 Moderate	Temporary, but reversible loss/ migration of species population (< 25%), habitat or ecosystem. Moderate mitigation efforts required for total reversal.	Temporary restriction < 10 years in duration with a moderate reduction in usage levels or quality of life; harm to cultural resources recoverable through moderate mitigation efforts. and/or The remediation associated with the environmental harm, asset damage and/or litigation/resolution costs are between $100,000 and $1 million.	Shelters in place but evacuation not mandatory. and/or State negative media exposure and/or Business interruption costs likely to be between $100,000 and $1 million.
2 Minor	Brief, but reversible loss/migration of species population (< 15%), habitat or ecosystem. Minor mitigation efforts required for total reversal.	Brief restriction < 5 years in duration with a minor reduction in usage levels or quality of life; minor harm to cultural resources that are recoverable through minor mitigation efforts. and/or The remediation associated with the environmental harm, asset damage and/or litigation/resolution costs are between $10,000 and $100,000.	Local notification only (selected phone calls, letter notification). and/or Local negative media exposure and/or Business interruption costs likely to be between $10,000 and $100,000.
1 Negligible	Some minor loss/ migration of species population (< 10%) habitat or ecosystem that are short term and immediately and completely reversible.	Restrictions on access without loss of resources; temporary but fully reversible impacts on quality of life; minor impact on cultural resources, landscapes, traditions that are fully reversible without lost value. and/or The remediation associated with the environmental harm, asset damage and/or litigation/resolution costs are between $0 and $10,000.	No communication to the public. and/or No media exposure and/or Business interruption costs likely to be between $0 and $10,000.

6.2.3.2 Likelihood of impact occurrence

The likelihood of an impact occurring takes into account the effective implementation of industry standard mitigation measures. The likelihood of the top-level event occurring that could give rise to the impact is based on industry experience.

The likelihood selection is based on the likelihood (i.e. probability or frequency) of a consequence occurring with safeguards in place.

The following table (**Table 6-5**) provides the likelihood descriptions that have been used for the risk review, which are based on the ConocoPhillips Risk Matrix. As outlined above, this process reflects the risk management process detailed within AS/NZS ISO 31000:2009 (AS/NZS 2009) and Handbook 203:2006 (AS/NZS 2006).

Table 6-5: Risk assessment likelihood definitions

Level	Descriptor	Description	Quantitative range per year*
1	Improbable	Virtually improbable and unrealistic	$<10^{-6}$
2	Remote	Not expected nor anticipated to occur	$10^{-6} – 10^{-4}$
3	Rare	Occurrence considered rare	$10^{-4} – 10^{-3}$
4	Probable	Expected to occur at least once in 10 years	$10^{-3} – 10^{-1}$
5	Frequent	Likely to occur several times a year	$>10^{-1}$

* The quantitative range is applicable only to assessing the risk of unplanned discharges in **Section 6.4.10**. The values in the quantitative range were used as guidance by subject matter experts in selecting the appropriate likelihood category for unplanned discharges.

6.2.4 Risk evaluation

Demonstration of acceptability

ConocoPhillips takes into account a range of considerations when evaluating the acceptability of environmental impacts and risks associated with its projects, including:

- the principles of ESD
- relevant environmental legislation, international agreements and conventions, guidelines and codes of practice
- internal context – alignment with ConocoPhillips HSEMS, HSE Policy, SD Position, and company standards and systems
- external context – potential environmental consequences and stakeholder expectations.

The linkage of the ConocoPhillips residual risk rankings and the demonstration of acceptability is outlined in **Table 6-6**.

Acceptability has been defined for each aspect of the project in **Section 6.4**, given the outcomes of the risk conclusions relevant to each aspect. An overall statement of acceptability for the project is provided in **Section 7.3**, which takes into account the above considerations.

Table 6-6: Residual risk ranking and acceptability

ConocoPhillips residual risk ranking	Acceptability
Low	*Broadly acceptable* Alignment with ConocoPhillips HSEMS and Company standards/systems. Relevant environmental legislation and standard industry practice will be applied to manage the risk and address reasonable regulator and stakeholder expectations. Management controls have been implemented to address the acceptability considerations.
Medium	*Acceptable* If management controls have been implemented to address the acceptability considerations, a medium residual risk ranking can be considered acceptable.
Significant and high	*Unacceptable* The activity (or element of) should not be undertaken as the risk is serious and does not meet the principles of ESD, legal requirements, ConocoPhillips' requirements or regulator and stakeholder expectations. The activity requires further assessment to reduce the risk to an acceptable level. If the residual risk is unable to be lowered to a more acceptable level, managerial review and approval is required.

6.2.5 Risk treatment

In order to take account of practical measures for the effective management of potential environmental impacts and risks to an acceptable level, the key management controls and systems that will be applicable throughout the project life-cycle were considered. The key management controls identified to mitigate the impacts and ricks associated with each of the key project aspects, are presented in **Section 6.4.1** to **Section 6.4.10**.

6.3 Environmental risk assessment workshops

A two-step multi-disciplinary risk review process has been undertaken to inform the evaluation of impacts and risks relevant to this OPP. This is outlined further in the following sub-sections.

6.3.1 Initial (screening) risk workshop

An initial risk assessment workshop was undertaken in July 2015 to inform the identification and preliminary evaluation of relevant environmental impacts and risks. This workshop was attended by a specialist team of marine and environmental scientists together with ConocoPhillips personnel and project managers who are integrally involved in the development of the proposed project.

Following a standardised risk assessment process, the assessment was completed to inform the initial identification of environmental impacts and risks associated with factor/aspect interactions by:

- broadly identifying potential key environmental factors/aspects
- undertaking a high-level risk review to inform the level of emphasis and detail required for the various environmental factors/aspects, to be carried through into the subsequent impact assessments
- completing a preliminary evaluation of all impacts and risks, appropriate to the nature and scale of each impact or risk.

As an outcome of the initial risk workshop, risk rankings (inherent and residual) and the rationale for the rankings were defined. Confidence levels were subsequently applied to the risk rankings based on the level of understanding of the values and sensitivities in the region from:

- availability of detailed scientific literature
- dedicated studies
- modelling
- expert engagement.

The level of understanding of the different project aspects was informed by:

- availability of detailed scientific literature
- industry experience and project definition limitations during early design
- availability of relevant guidelines and standards
- technology available (i.e. existing, proven technology versus relatively new technology).

Residual risk was also determined based on the ability to define likelihood and consequence based on extent, duration and frequency of the risk or impact, and presence of environmental values and sensitivities.

The assignment of confidence levels to the initial risk rankings identified those areas where further information was required to make an informed assessment prior to the final risk rating workshop, i.e. where there was considered to be low/medium confidence in the rating. These lower confidence ratings related to a number of acknowledged gaps such as the lack of published information on a specific factor, the requirement to complete modelling associated with specific planned and unplanned aspects, or the level of detail during early design.

The additional knowledge gathering addressed the identified gaps and took the form of:

- modelling studies to inform the assessment of potential in-field impacts from planned or unplanned activities
- further targeted engagement with recognised experts in key discipline areas to further inform understanding of the existing baseline beyond the published literature
- ongoing interpretation of the comprehensive geophysical and environmental baseline surveys of the Barossa offshore development area and surrounding features of environmental interest.

As new data and information became available, the process accommodated an iterative review of the confidence rankings, to inform a refined risk assessment summarised below.

6.3.2 Final (detailed) risk workshop

When further information was available for the key factors and aspects, such that a high level of confidence could reasonably be applied, a second risk rating workshop was held in February 2016. The workshop was attended by a suite of specialist marine and environmental scientists together with ConocoPhillips personnel and project managers. The workshop confirmed the inherent and residual risk ratings for all impacts, and focused on those key impacts and risks that had been identified as medium/high/ significant inherent risk or low/medium confidence in the initial risk workshop. The outcomes of the workshop provided a detailed assessment of the key impacts and risks, in light of additional baseline study information and modelling outputs, together with a project-level definition of environmental outcomes and acceptability.

This dual-stage risk review process demonstrates a rigorous and systematic approach which provides confidence of a reasonable basis for the identification and evaluation of environmental impacts and risks. The assessment of impacts and risks for the project continued to be iteratively reviewed by the project team as further engineering definition became available, to confirm the environmental risk profile represents the development option(s) carried through in the scope of this OPP.

Section 6.4 details the environmental aspects of the project and identifies the degree of inherent and residual risk that has been assessed as relevant to the related impacts. A summary of the risk ratings related to these aspects and factors is provided in **Table 6-7**.

Table 6-7: Project aspect and factor interaction matrix

Aspect	Physical environment (including seabed features, water, sediment and air quality and underwater noise)	Shoals and banks (e.g. Evans Shoal, Tassie Shoal, Lynedoch Bank, Goodrich Bank, Marie Shoal and Shepparton Shoal)	Tiwi Islands	Other offshore reefs, islands and NT/WA mainland coastline	Marine mammals	Marine reptiles (turtles and sea snakes)	Birds (seabirds and migratory shorebirds)	Fish (pelagic and demersal)	Sharks and rays	Plankton	AMPs	KEFs	Commonwealth heritage places	Marine archaeology	Commercial fishing	Recreational and traditional fishing (Tiwi Islands)	Tourism, recreation and scientific research	Commercial shipping	Offshore petroleum exploration and operations	Defence activities (NAXA)
Physical presence of offshore facilities/infrastructure, equipment and project related vessels – interactions with other marine users															Green	Green		Green	Green	
Physical presence of offshore facilities/infrastructure, equipment and project related vessels – interactions with marine fauna					Green	Green	Green	Green	Green											
Seabed disturbance – Barossa offshore development area	Green	Green									Green	Green								
Seabed disturbance – gas export pipeline corridor	Yellow	Yellow				Yellow					Yellow	Yellow								
IMS (biosecurity)		Green	Green		Green	Green		Green	Green		Green	Green			Green					
Underwater noise emissions					Green	Green		Green	Green	Green					Green					
Atmospheric emissions	Green																			
Light emissions					Green	Green	Green	Green	Green											
Planned discharges	Green	Green			Green	Green	Green	Green	Green			Green								
Waste management	Green				Green	Green	Green	Green	Green											
Unplanned discharges – Barossa offshore development area[1]	Yellow	Yellow		Green	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Yellow	Yellow	Green	Yellow	Green	Green	Yellow	Yellow	Yellow
Unplanned discharges – gas export pipeline corridor[2]	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green		Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow

Key

White	Interaction not reasonably expected
Green	Interaction reasonably possible – low residual risk and high/medium confidence
Yellow	Interaction reasonably possible – medium residual risk and high/medium confidence
Orange	Interaction reasonably possible – high/significant residual risk and high/medium confidence

1 Based on the maximum credible spill modelling scenario (i.e. long-term subsea well blowout in the Barossa offshore development area; **Section 6.4.10.9**)

2 Based on the maximum credible spill modelling scenario (i.e. vessel collision during pipelay in the vicinity of the Tiwi Islands; **Section 6.4.10.11**)

6.4 Risk assessment of key project environmental impacts and risks

The following sections provide a detailed assessment and evaluation of the key environmental impacts and risks associated with the project. The potential impacts are identified and discussed in detail, and the inherent and residual risk ratings (with the consequence and likelihood rankings) presented. **Table 6-7** provides a summary overview of the key aspects associated with the project and their potential to impact environmental values/sensitivities, with the colour-coding representing the residual risk concluded from the assessment.

A detailed assessment has been conducted for all development drilling, installation, pre-commissioning, commissioning and operation related activities, and details of decommissioning-related impacts and risks have been provided for key aspects (**Sections 6.4.2** and **6.4.5**). Potential impacts associated with decommissioning will depend upon the chosen strategy to be confirmed nearer the time of decommissioning (**Section 4.3.4**). A decommissioning EP will be developed prior to commencement of decommissioning activities and will be subject to acceptance by NOPSEMA (**Table 7-1**).

6.4.1 Physical presence – interactions with other marine users

The physical presence of offshore facilities/infrastructure, equipment and related vessel movements associated with the project has the potential to interact with other marine users. The risk assessment for potential impacts to other marine users is summarised in **Table 6-8**.

Table 6-8: Physical presence – interactions with other marine users risk assessment

Risk	Physical presence of the project and vessel movements within the project area (both short term during construction and long term during operations) interacting with other marine users, such as commercial fishing, commercial shipping, and offshore petroleum exploration and operations.		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor		
Key project stage	All – particularly operations		
Key factor(s) (see Table 6-7)	Commercial fishing		
	Recreational and traditional fishing		
	Commercial shipping		
	Offshore petroleum exploration operations		
Other relevant factor(s) (see Table 6-7)	N/A		
Potential impact(s)	• Interference with and/or exclusion of commercial/recreational fishing vessels, commercial shipping or other marine users. • Business interruption (abnormal) to the activities of other marine users due to damage to commercial vessels or fishing gear. • Interaction with other petroleum titleholder operations or exploration activities.		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	2 Minor (Bus)	2 Remote	4 Low
Residual risk	2 Minor (Bus)	2 Remote	4 Low
Confidence	High		

Impact assessment and risk evaluation

The project will result in the physical presence of facilities and equipment during installation and operations, with key elements including the MODU/drill ship, FPSO facility, in-field subsea infrastructure and a gas export pipeline. A number of vessels will be required to support the project throughout its life. While vessel types and numbers are likely to be highest on an annualised basis during installation activities, total vessel movements will be greater over time during operations given the life of the project. Vessel movements during operations will be predominantly associated with the FPSO facility. The presence of project facilities/equipment and vessel movements has the potential to result in interactions with other marine users such as commercial fishers.

Commercial fishing

Impacts from interactions from project facilities/infrastructure and vessel movements with other marine users throughout the project are considered remote given the relatively minor physical scale of the offshore facilities/infrastructure (i.e. MODU/drill ship, FPSO facility and gas export pipeline) and presence of project-related vessels, combined with the relatively low level of activity within the open offshore waters of the project area. Through engagement with commercial fisheries that occur within the project area, it has been determined that the Barossa offshore development area is not intensively fished by the Timor Reef Fishery. The areas actively fished by the Northern Prawn Fishery in nearshore waters are a minimum of approximately 64 km from the Barossa offshore development area, and therefore will not be affected (**Figure 5-24**). The gas export pipeline corridor overlaps approximately 793 km^2 of the area actively fished in the Northern Prawn Fishery at low intensity (**Figure 5-24**). However, the actual area of overlap will be significantly smaller than this (in the order of approximately 0.18 km^2) given the narrow width and linear nature of the gas export pipeline (24–26 inches). The gas export pipeline corridor does not intersect any areas trawled by the NT demersal fishery (**Figure 5-23**). Considering the relatively short duration of the pipeline installation (6–12 months in which higher numbers of vessels will be present), and minimal number of project related vessel movements within the gas export pipeline corridor during operations (i.e. limited to periodic maintenance and inspection activities), the impact to commercial fishing activities from vessels movements are considered to be minor.

Consultation with commercial fishers of the Timor Reef Fishery undertaken in late 2015/16, in relation to an appraisal drilling campaign and 3D seismic survey, identified some concerns regarding the physical presence of vessels during periods of peak fishing activity (October and May) and the potential for disruption of their activities. Through the consultation process it was noted that potential impacts for trap fishers would have been greater if activities were over fishing grounds further to the south-west (> 50 km away). ConocoPhillips will continue to undertake consultation with relevant stakeholders both broadly as part of this OPP and in more detail prior to the preparation of activity-specific EPs, as part of the Stakeholder Engagement Plan.

Recreational fishing

Recreational fishing practices are typically observed near/around the shoal/bank, reef and island features in the region. Consequently, these practices are generally expected to be geographically separate from planned project activities in the Barossa offshore development area, specifically in locations where physical presence of offshore facilities/infrastructure and project vessels could occur.

Consultation undertaken for the 2016/17 seismic and appraisal drilling campaigns in the Bonaparte Basin identified one fishing charter company that conducts tours in the broader area, particularly in the open offshore waters in the vicinity of Evans Shoal and Goodrich Bank during the main fishing season (September to December). The physical presence of the project, including project vessels, is expected to have limited impact on these activities considering the distance from the Barossa offshore development area (approximately 35 km from Evans Shoal), reasonably small exclusion zone around the offshore facilities/infrastructure in open offshore waters (e.g. approximately 500 m radial exclusion zone around the operational FPSO facility and in-field infrastructure), and relatively short installation period required for the gas export pipeline in the vicinity of Goodrich Bank. Further engagement will be undertaken with relevant stakeholders going forward, as the project progresses.

Traditional fishing

Similar to recreational fishing, traditional fishing activities are typically concentrated near/around the shoal/bank, reef and island features of the region. As discussed in **Section 3.6**, Indonesia exercises EEZ sovereign rights over the water column in the Perth Treaty area, where traditional Indonesian fishing occurs. The Perth Treaty is unlikely to be affected by the physical presence of infrastructure within the Barossa offshore development area for similar reasons as those described above relating to interactions with other marine users. The location of the FPSO facility in deep waters and the small exclusion zone established around project infrastructure will not preclude traditional Indonesian fishers from traversing the Perth Treaty area during their passage from Indonesia to the shoals/banks.

In addition to the broader consultation efforts outlined above with other marine users, ConocoPhillips will comply with the requirements of Article 7 of the Perth Treaty by engaging with Indonesia to provide at least three months' notice of the grant of exploitation rights. As outlined in **Section 3.6**, communications with the Indonesian Government on these matters is conducted by DFAT in Canberra. DFAT will advise ConocoPhillips of any Operator requirements related to these communications, either direct to ConocoPhillips or via the National Offshore Petroleum Titles Authority.

Commercial shipping

The presence of project vessels during installation has the potential to cause temporary disruption to commercial shipping. The Barossa offshore development area and the majority of the gas export pipeline corridor do not overlap with any major commercial shipping channels (**Section 5.7.17**). The southern end of the proposed pipeline, where it ties into the existing Bayu-Undan to Darwin gas export pipeline, is in an area of high shipping traffic due to its proximity to Darwin. All shipping vessels will be required to comply with the International Regulations for Preventing Collisions at Sea 1972 and may therefore need to deviate slightly to avoid the project activities (e.g. installation of the southern extent of the gas export pipeline in the vicinity of the Tiwi Islands) if required to travel within the vicinity of the project. As outlined above, ConocoPhillips will undertake consultation with relevant stakeholders as the project progresses to ensure they are aware of the project and the proposed timing of key activities which may affect them.

The total number of trading vessels (includes dry bulk, container, general cargo, petroleum, livestock, rig tender or offshore oil and gas support vessels) visiting Darwin Port during 2013/14 was equal to 3,178 visits (Darwin Port Corporation 2014). This represents an increase of 15% from the previous year and 49% since 2008/09. A large portion of the increase was attributable to the vessels used in INPEX's dredging program for the Ichthys project. Although these figures provide an indication of vessel movements in the area, most marine traffic is made up of non-trading vessels such as naval vessels, research and recreational craft, fishing and fishing supply vessels. For example, in 2007/08 trading vessels represented only 29% of the total recorded vessels visiting the Darwin Port (Darwin Port Corporation 2009). Vessel movements associated with the installation of the gas export pipeline are expected to represent an increase of approximately 20% in the total number of trading vessels visiting Darwin Harbour (based on 2013/14 records) over the 6–12 month period. Whereas vessel movements to the Barossa offshore development area during operations will represent less than a 4% increase on 2013/14 records for trading vessels visiting Darwin Harbour.

The low volume of marine traffic related to Port Melville (Melville Island) operations (**Section 5.5.17**) is unlikely to interact with project vessels, given the separation distance from the Aspley Strait where most vessels enter/exit port, and low vessel movements.

As outlined in **Section 6.4.1**, the location of the FPSO facility will be communicated to other ships through a Notice to Mariners from the AHO. Given the vast area of open ocean surrounding the Barossa offshore development area, the impact to marine users is considered to be very minor.

Other petroleum operations

While the gas export pipeline corridor traverses a number of offshore petroleum permits held by other oil and gas companies, the Barossa offshore development area is not in close proximity to any existing or proposed operational offshore facilities or infrastructure owned by other oil and gas operators. Exploration activities in the surrounds of the gas export pipeline may be subject to minor deviations during installation and there will be restrictions on the placement of future infrastructure should the development of other offshore fields occur. However, considering the large open offshore environment, the likelihood of potential impacts to other oil and gas companies is considered remote and the risk is low.

Impact and risk summary

A summary of the potential impacts to other marine users, proposed key management controls, acceptability and EPOs for physical presence (including vessel movements) are presented in **Table 6-9**. In conclusion, the residual risk of impacts to other marine users as a result of the physical presence of the project and vessels is considered low given there are no areas of importance for commercial fishing and other marine users within the physical footprint of the project infrastructure. Communication with commercial shipping and other marine users will also be maintained.

There are no relevant requirements within any EPBC management plans/recovery plans or conservation advices that are of direct relevance to physical presence and potential interactions with other marine users. Relevant requirements of EPBC management plans/recovery plans or conservation advice of relevance to physical presence interactions with marine fauna are discussed in **Section 6.4.2**.

Table 6-9: Summary of impact assessment, key management controls, acceptability and EPOs for physical presence – interactions with other marine users

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
Physical presence of offshore facilities/ infrastructure, equipment and project related vessels – interactions with other marine users	Commercial fishing. Recreational fishing. Commercial shipping. Offshore petroleum exploration operations.	Interference with and/or exclusion of commercial/ recreational fishing vessels, commercial shipping or other marine users. Business interruption (abnormal) to the activities of other marine users due to damage to commercial vessels or fishing gear. Interaction with other petroleum titleholder operations or exploration activities.	The project will comply with the *OPGGS Act 2006* – Section 616 (2) Petroleum safety zones, which includes establishment and maintenance of a petroleum safety zone around the well, offshore structure or equipment which prohibits vessels entering or being present within the specified area without written consent. Accepted procedures will be implemented to meet the requirements of ConocoPhillips' Marine Operations Manual (IOSC/OPS/HBK/0003), which includes details of: • roles, responsibilities and competency requirements • requirements (e.g. storage, transfer) for bulk cargo and bulk liquids (including bunker fuel) operations • general requirements for entering/departure and movement within the designated exclusion or petroleum safety zones • checklist required to be completed for vessels entering the exclusion zones in the development area • safe and sustainable dynamic positioning operations. The Stakeholder Engagement Plan will include consultation with commercial fisheries, shipping, Australian Hydrographic Office (AHO) and other relevant stakeholders operating in the Barossa offshore development area and gas export pipeline to inform them of the proposed project. Ongoing consultation will also be undertaken throughout the life of the project. The FPSO facility will be located away from key commercial shipping channels. The location of the FPSO facility will be communicated to other ships through a Notice to Mariners from the AHO. Subsea infrastructure and pipelines will be clearly marked on Australian nautical charts published by the AHO. Project-vessels operating within the Barossa offshore development area and gas export pipeline corridor will comply with maritime standards such as COLREGS, Chapter V of SOLAS, Marine Order 21 (Safety of Navigational and Emergency Procedures) and Marine Order 30 (Prevention of collisions) (as appropriate to vessel class).	The potential impacts and risks associated with the physical presence of the project and vessels are considered broadly acceptable given: • The residual risk is considered low as: ◦ there are no areas of significant importance for commercial fishing or other marine users within the physical footprint of the project infrastructure. • The key management measures are considered effective in managing potential impacts associated with the physical presence of the project and related vessels. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements.	Fixed offshore facilities/ infrastructure and equipment in the Barossa offshore development area will not be located in key areas of importance for commercial fishing and other marine users. No vessel collisions or significant adverse interactions with other marine users.

6.4.2 Physical presence – interactions with marine fauna

The physical presence of offshore facilities/infrastructure, equipment and vessels operating within the project area have the potential to interact with marine fauna, particularly marine mammals and reptiles. The risk assessment for potential impacts to marine fauna is summarised in **Table 6-10.**

Table 6-10: Physical presence – interactions with marine fauna risk assessment

Risk	Physical presence of the project and vessel movements within the project area (both short term during construction and long term during operations) interacting with marine fauna.		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor		
Key project stage	All		
Key factor(s) (see Table 6-7)	Marine mammals	Marine reptiles	
Other relevant factor(s) (see Table 6-7)	Birds Fish	Sharks and rays	
Potential impact(s)	• Injury or mortality of conservation significant fauna. • Change in marine fauna behaviour and movements.		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	2 Minor (Bus)	2 Remote	4 Low
Residual risk	2 Minor (Bus)	2 Remote	4 Low
Confidence	High		

Impact assessment and risk evaluation

As outlined in **Section 6.4.1**, the project will result in the physical presence of facilities/infrastructure and equipment, and vessel movements will occur within the project area. While vessel types and numbers are expected to be highest on an annualised basis during installation activities, total vessel movements will be greater over time during operations and will be predominantly associated with the FPSO facility.

Offshore facilities/infrastructure and equipment

The in-field subsea infrastructure and gas export pipeline are unlikely to significantly affect marine fauna behaviour and movements given their location on the seabed. The presence of the FPSO facility (at the sea surface) and risers (within the water column) represent small surface and mid-water obstacles in an open ocean environment with no natural obstructions to movement in the vicinity. Therefore, there is the potential for these obstacles to result in very minor and localised deviations by marine fauna. However, it is expected that migratory movements and patterns at a population level will not be affected given that there are no regionally significant areas for marine fauna in the Barossa offshore development area.

Given the limited scale and cross-sectional area of the project elements in a broader regional context, it is considered highly unlikely that the presence of the project will result in significant changes in habitat usage by marine species transiting the area or to the physical environment, such as regional currents and food resource availability.

In general, given the offshore location of the proposed FPSO facility and associated in-field infrastructure in open waters which are distant from shoals/banks, reefs and islands, the numbers of marine fauna passing through the area are expected to be low. The Barossa offshore development area does not contain any regionally significant feeding, breeding or aggregation areas for marine fauna. The closest regionally important shoals/banks that are likely to provide important habitat for various marine fauna species (e.g. marine turtles, sea snakes, fish and sharks) are Lynedoch Bank (approximately 27 km east of the Barossa offshore development area), Tassie Shoal (approximately 32 km west), and Evans Shoal (approximately 35 km west). These areas will not be affected by the physical presence of the facilities/infrastructure within the Barossa offshore development area given the open ocean context. The inclusion of cooling water screens on intakes will also mitigate the risk of fauna ingress into the FPSO facility.

The southern end of the proposed export pipeline corridor crosses a portion of internesting habitat critical to the survival of flatback turtles and olive ridley turtles (**Figure 5-18**), overlaps a portion of the internesting BIA for flatback turtles and is adjacent to the internesting BIA for olive ridley turtles (**Figure 5-17**). However, the physical presence of the pipeline during operations is considered highly unlikely to impact the species use of the area, considering the area affected represents a small portion of the internesting habitat critical to the survival of these species (in the order of approximately < 0.3 km^2 for the direct physical footprint of the pipeline or approximately < 0.0001% for flatback turtles and approximately < 0.1 km^2 for the direct physical footprint or approximately < 0.0015% for olive ridley turtles). The pipeline corridor does not intersect any biologically important areas for other marine fauna. Therefore, while individuals may transit the project area, no impacts are expected at a population level to marine fauna, particularly EPBC listed species.

Overall, potential impacts to marine fauna as a result of the physical presence of the project are considered minor and the risk is low.

Vessel movements

The risk of vessel strike to marine fauna is inherent to movements of all vessel types, including recreational vessels, fishing vessels, passenger ships, whale-watching boats, container ships and naval ships. A review of records of vessel collisions with marine megafauna reported a higher number of collisions with whale-watching boats, naval ships and container ships (DoEE 2016).

The recovery plans and conservation advices for whales (blue, humpback, sei and fin whales) and marine turtles (flatback, olive ridley, green, loggerhead, hawksbill, leatherback) recognise vessel strikes/disturbance as a key threat to these EPBC listed species (**Table 3-2**). It is noted that the Recovery Plan for Marine Turtles in Australia considered both vessel strikes with turtles and disturbance to important benthic feeding and internesting behaviours (DoEE 2017a).

Vessels associated with the project may present a potential risk to marine fauna. The impact from vessel interactions with marine fauna can be as minimal as temporary behavioural changes, ranging to severe impacts, such as injury or mortality resulting from vessel strikes. The potential risk of a collision with marine fauna is directly related to the abundance of marine fauna and number of vessels in the project area, and the actual likelihood of a collision occurring is also influenced by vessel speed. As presented in DoEE's Draft National Strategy for Mitigating Vessel Strike of Marine Megafauna (DoEE 2016), **Figure 6-3** shows the approximate locations of reported vessel collisions for whales in Australian waters between 1990 and 2015. The majority of the reported vessel collisions have occurred along eastern or south-eastern Australia, with no reported incidences in NT waters (DoEE 2016).

Vessel speed has been demonstrated to be a key factor in relation to collision with marine fauna, particularly cetaceans and turtles, with faster moving vessels posing a greater collision risk than slower vessels (Laist et.al 2001; Jensen and Silber 2003; Hazel 2009). Laist et al. (2001) suggest that the most severe and lethal injuries to cetaceans are caused by vessels travelling at 14 knots or faster. Turtles will typically avoid vessels by rapidly diving, however, their ability to respond varies greatly depending on the speed of the vessel. Hazel (2009) reported that the number of turtles that fled vessels decreased significantly as vessel speed increases. Turtles are also adapted to detect sound in water (Popper et al. 2014) and will generally move from anthropogenic noise generating sources, including vessels, within their detection range (pers. comm. M. Guinea, CDU, 2015).

The behaviour of the individual may also influence the potential for a collision with a vessel. For example, it has been suggested that individual whales engaged in feeding, mating or nursing behaviours may be more vulnerable to vessel collision as they are distracted by these activities and consequently less aware of their surroundings (Laist et al. 2001). A study on the behavioural responses of blue whales to vessels showed limited behavioural response when being approached by ships (McKenna et al. 2015, cited in DoEE 2016).

The potential for marine fauna to be affected by vessel movements throughout the life of the project is considered low and the number of individuals likely to be affected is limited. The Barossa offshore development area does not contain any significant feeding, breeding or aggregation areas and is relatively distant from shoals/banks, reefs and islands. Therefore, it is expected that there will be a relatively limited abundance of individuals, particularly EPBC listed species, present in the Barossa offshore development area at any time with individuals likely to be passing through the area. In addition to limited abundance, the seasonal presence of whale species also influences the potential for interactions with vessels. Bryde's whales were observed to be present in the Barossa offshore development area from January to early October, with pygmy blue whales detected between late May and August (JASCO 2016a). While some species may be present in the Barossa offshore development area in greater numbers at certain times of the year, the numbers overall are low. Considering this, and the wide distribution of whale species, vessel movements are not anticipated to cause any effects at a population or migration level. In addition, vessels within defined operational areas in the Barossa offshore development area will be travelling at relatively low speeds and proactively respond to fauna interactions in line with the requirements of EPBC Regulations 2000 - Part 8 Division 8.1.

It is well understood that the primary migratory route for humpback whales is near the Kimberley coastline and up to Camden Sound (**Section 5.6.2**). Relatively few humpback whales have been known to travel north of Camden Sound (Jenner et al. 2001), which is located more than approximately 820 km south-west of the Barossa offshore development area. Noise monitoring in the Barossa offshore development area also did not record any humpback whales. Therefore, it is highly unlikely that project-related vessels in the project area will interact with this species.

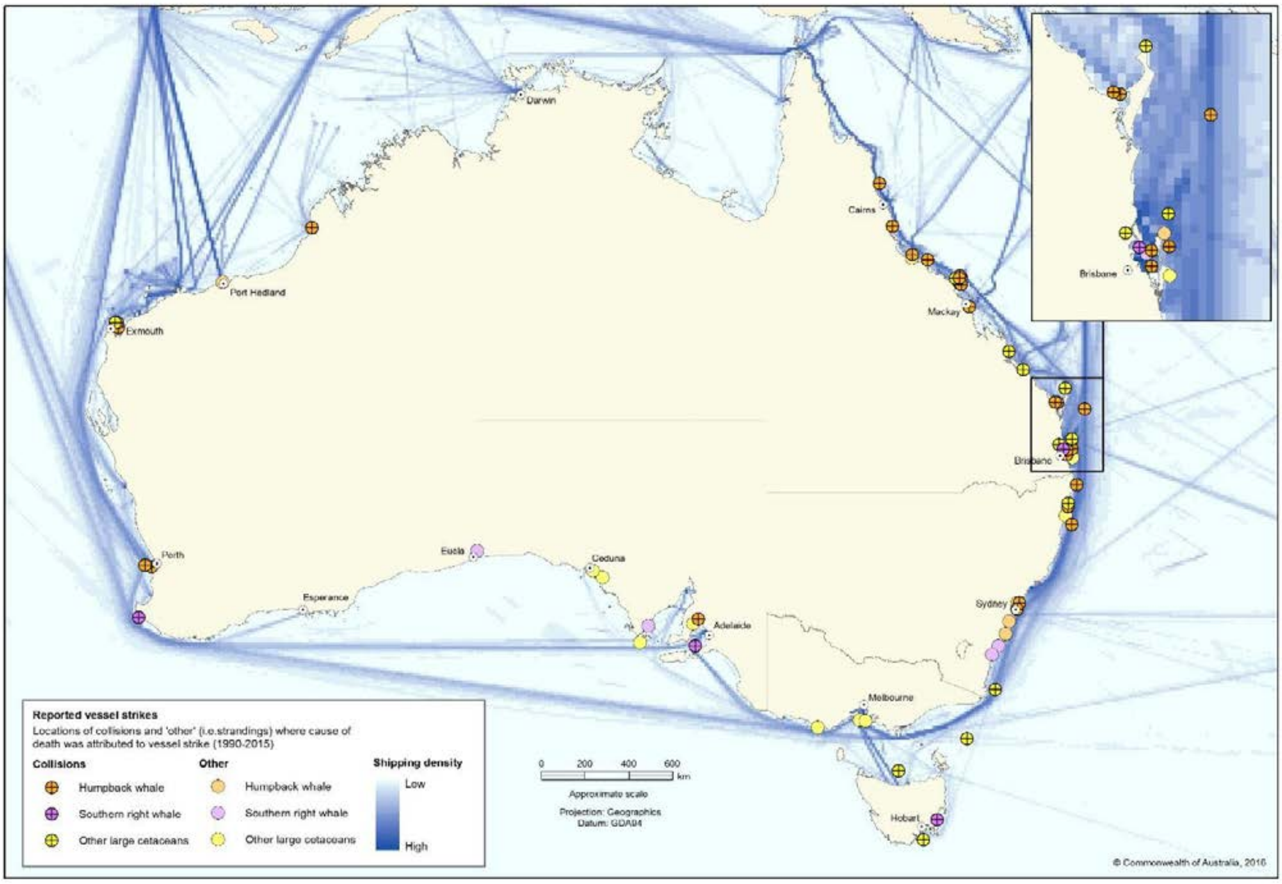
Both sei and fin whales have a wide distribution throughout offshore waters and therefore may pass through the project area in low numbers (**Section 5.6.2**). However, considering the relatively slow vessel speeds within the project area, and the mobility of these species, it is highly unlikely that project vessels will adversely interact with any individuals.

Turtles are at risk of a vessel strike while they are resting or returning to the sea surface to breathe. However, it has been noted that turtles spend relatively limited (3–6%) time at the surface, with dive times generally lasting 15 to 60 minutes (Milton and Lutz 2003, cited in Woodside 2014). Considering the offshore location of the Barossa offshore development area and the distance to the closest shallow feeding/breeding habitats at the Tiwi Islands (approximately 100 km south), the risk of injury from vessel strikes to turtles which may be passing through the area is considered low as few individuals are expected in the area.

The southern end of the proposed export pipeline corridor traverses internesting habitat critical to the survival of flatback and olive ridley turtles (**Figure 5-18**), overlaps a portion of the internesting BIA for flatback turtles and is adjacent to the internesting BIA for olive ridley turtles (**Figure 5-17**). Therefore, there may be an increase in number of individuals in this area (between June to September for flatback turtles and April to August for olive ridley turtles) that are at risk from a vessel strike. The pipelay vessel will be travelling at very low speeds as it expected to lay in the order of approximately 3 km–5 km of the gas export pipeline per day. Therefore, the risk of coming into contact with turtles is low as it is expected turtles will dive or move away from the vessels. The installation of the gas export pipeline is also expected to take in the order of 6 to 12 months, with installation within the internesting habitat critical to the survival of olive ridley turtles expected to take approximately one to two months. Consequently, the likelihood of a vessel strike and the possibility of injury/mortality to individual turtles within the project area is considered remote. However, if any vessel strikes do occur they are unlikely to threaten the overall viability of the population as the plausible number of vessel strikes is small when compared to the overall population sizes for turtles. The Recovery Plan for Marine Turtles in Australia notes that while a vessel strike can be fatal for an individual turtle, vessels strikes (as a standalone threat) have not been shown to cause declines at a population or stock level, and have considered vessel disturbance to be of minor consequence to turtle populations in the NT (DoEE 2017a). The implementation of vessel speed restrictions within the defined operational area of the gas export pipeline route, and crew training to sight and manage interactions with turtles, will also minimise the risk of vessel collisions with individual turtles that may be present in the area. During operations, vessel movements associated with the project within the gas export pipeline corridor will be minimal and limited to those required for periodic maintenance and inspection activities. Therefore, general marine traffic will contribute to the majority of the vessel movements in the area.

While sea snakes may be in the project area, they are more commonly distributed in shallow inshore regions and islands or waters surrounding shoals/banks, reefs and offshore islands, which provide suitable seabed habitat and clear waters (Guinea 2013). Therefore, it is considered highly unlikely that vessel movements will cause disturbance of these conservation significant fauna individuals due to the offshore location of the project area. In addition, the relatively low speeds of vessels associated with the project are expected to allow individuals time to move away or dive.

A section of the pipeline corridor passes through the Oceanic Shoals marine park (approximately 70 km of the 260 km–290 km route). Vessels movements associated with the installation of the gas export pipeline will only affect the marine park for a relatively short period of time (within the expected 6–12 month installation period).



(source: DoEE 2016g)

Figure 6-3: Location of reported vessel collisions with whales or other incidents attributed to vessel collision

Impact and risk summary

In conclusion, the residual risk of impact to marine fauna from the physical presence of the project and vessels is considered low given the controls outlined above to limit vessel speeds and the fact that there are no regionally significant feeding, breeding or aggregation areas for marine fauna within the Barossa offshore development area. While the southern end of the gas export pipeline route will cross a portion of internesting habitat critical to the survival of flatback and olive ridley turtles, installation activities are of a relatively limited duration (within the order of 6–12 months, but only approximately one to two months in the habitat critical to the survival of olive ridley turtles), will avoid the internesting BIA for olive ridley turtles and installation vessel speeds are low and seasonal activity will be taken into account as part of forward planning.

The project is considered consistent with the relevant requirements of the Blue Whale Conservation Management Plan, Humpback Whale Recovery Plan 2005-2010 (under review), Recovery Plan for Marine Turtles in Australia and relevant marine fauna species conservation advices as related to physical presence (**Table 6-11**). A summary of the potential impacts, proposed key management controls, acceptability and EPOs for physical presence and interactions with marine fauna are presented in **Table 6-12**.

Table 6-11: Summary of alignment with relevant EPBC management plans for physical presence – interactions with marine fauna

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)

Marine mammals - Blue whale	Blue Whale Conservation Management Plan (October 2015) (DoE 2015a)	Demonstrably minimise anthropogenic threats, including impacts associated with the presence of oil and gas platforms/rigs.	• The impacts from physical presence of offshore infrastructure and project related vessels interacting with marine fauna have been demonstrably minimised through implementation of the key management controls of:
			  • placement of offshore infrastructure in areas where there are no regionally significant feeding, breeding or aggregation areas for marine mammals
			  • limiting the physical footprint of the project to a very small proportion of the habitat available for these species, therefore displacement of individuals is unlikely and the likelihood of a collision is remote
			  • vessels travelling at relatively low speeds within defined operational areas
			  • project vessels proactively responding to potential fauna interactions in line with the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1.
			• Impacts from the presence of offshore infrastructure and related vessels interacting with marine fauna are not considered to present a significant risk at a population level.

		Minimising vessel collisions.	
		Consider the risk of vessel strikes on blue whales when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, implement appropriate mitigation measures.	
Marie mammals - Sei whale	Conservation advice (October 2015) (DoE 2015c)	Minimise vessel collisions.	
Marine mammals - Fin whale	Conservation advice (October 2015) (DoE 2015d)	Minimise vessel collisions.	
Fish - Whale shark	Whale shark Recovery Plan 2005-2010 (May 2005) (DEH 2005b) Conservation advice (October 2015) (DoE 2015i)	No specific actions or requirements are identified.	

Marine mammals - Humpback whale[1]	Humpback Whale Recovery Plan 2005-2010 (May 2005) (under review) (DEH 2005a)	Minimise vessel collisions.	• The risk of project vessel collisions with humpback whales is considered low due to:
			  • the fact that there are no regionally significant feeding, breeding or aggregation areas for humpback whales within the project area
			  • the physical footprint of project infrastructure is limited to a very small proportion of the habitat available for this species, therefore the likelihood of a collision occurring is remote.

	Conservation advice (October 2015) (DoE 2015b)	Consider the risk of vessel strike when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required, implement appropriate mitigation measures to reduce the risk of vessel strike.	• Mitigation measures to further reduce the risk of vessel strike include:
			  • vessels travelling at relatively low speeds within defined operational areas
			  • project vessels proactively responding to potential fauna interactions in line with the requirements of the EPBC Regulations 2000 - Part 8 Division 8.1.
			• Vessel collisions with marine fauna are not considered to present a significant risk at a population level.

		Implement education programs to inform marine users (including shipping crews using important habitat) about best practice behaviours and regulations when interacting with humpback whales.	• All project personnel will be subject to project inductions which will address the requirements for vessel operators in relation to interactions with marine fauna.
Marine reptiles – Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (June 2017) (DoEE 2017a)	Manage infrastructure and coastal development to ensure ongoing biologically important behaviours for marine turtle stocks continue.	• There are no regionally significant feeding, breeding or aggregation areas for turtles within the Barossa offshore development area. • The physical presence of the gas export pipeline during operations is considered highly unlikely to impact the species use of the area, considering the area affected represents a very small portion of the internesting habitat critical to the survival of flatback turtles (0.0001%) and olive ridley turtles (0.0015%) respectively. • Therefore, there is widespread habitat available in the immediate vicinity that marine turtles could continue to use and the potential impacts are unlikely to impact biologically important behaviours or prevent those behaviours from occurring and no impacts to marine turtles at a population/ genetic stock level are expected.

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
		Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of the species. Manage anthropogenic activities in biologically important areas to ensure that biologically important behaviour can continue. (note, vessel disturbance for the flatback Arafura stock and olive ridley NT stock is rated as a moderate threat)	• There are no regionally significant feeding, breeding or aggregation areas for turtles within the Barossa offshore development area. • The gas export pipeline corridor intersects 3.7% and 3.2% of internesting habitat critical to the survival of flatback and olive ridley turtles, respectively, and 1.6% of the biologically important internesting area for flatback turtles. Installation activities associated with the gas export pipeline are of short duration and the number of vessels used are minimal when compared to the existing vessel traffic in the area (**Figure 5-26**). Therefore, even if a marine turtle was to move from the immediate location of installation activities, there is widespread internesting habitat available in the immediate vicinity that marine turtles could continue to use within the identified habitat critical and the potential impacts are not expected to impact biologically important behaviours or prevent those behaviours from occurring. • No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. • The plan states that *'Although the outcome can be fatal for individual turtles, boat strike (as a standalone threat) has not been shown to cause stock level declines.'*. Considering this, and the short term nature of the pipeline installation activities (6–12 months), impacts at a population/genetic stock level are not expected. • Vessel speed restrictions will be applied within defined operational areas, and crew training to sight and manage interactions with turtles, will minimise vessel disturbance to individual turtles that may be present. It is concluded that the implementation of management controls will allow the activities to be managed to ensure marine turtles are not displaced from identified habitat critical to their survival and that biologically important behaviour can continue.
Sharks and rays - Great white shark	Recovery Plan for the White Shark (*Carcharodon carcharias*) (August 2013) (DSEWPaC 2013a)	No specific actions or requirements are identified for assessing the threat of habitat modification/degradation for these species as a result of development, as relevant to the project.	• There are no regionally significant feeding, breeding or aggregation areas for sharks (including river sharks and sawfish) in the project area. • The physical footprint of the project is limited to a very small proportion of the habitat available for these species and, therefore, displacement of individuals is unlikely.
Sharks and rays - Grey nurse shark	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (August 2014) (DoE 2014a)		
Sharks and rays - Speartooth shark Northern river shark Green sawfish Largetooth sawfish Dwarf sawfish	Sawfish and River Sharks Multispecies Recovery Plan (November 2015) (DoE 2015j) Conservation advice: speartooth shark (April 2014) (DoE 2014b), northern river shark (April 2014) (DoE 2014c), dwarf sawfish (October 2009) (DEWHA 2009) and green sawfish (2008) (DEWHA 2008b)	Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification.	

[1] Although the species were identified in the EPBC Protected Matters search they are highly unlikely to occur in the project area, which is outside the species range or preferred habitat (see **Section 5.6.2** for humpback whales). However, the species may occur within the area of influence.

Table 6-12: Summary of impact assessment, key management controls, acceptability and EPOs for physical presence – interactions with marine fauna

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome

Physical presence of offshore facilities/ infrastructure, equipment and project related vessels – interactions with marine fauna	Marine mammals.
	
	Marine reptiles.
		Injury or mortality of conservation significant fauna.
		
		Change in marine fauna behaviour and movements.
			The project will be undertaken in accordance with ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as:
			• design planning throughout concept select phase to avoid placement of facilities/ infrastructure within the Barossa offshore development area in areas of regional environmental importance (e.g. shoals/banks, coral reefs, islands, and known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles).
			• use of gas export pipeline selection route surveys to inform route optimisation and reduce environmental impact.
			
			Screens will be installed on the FPSO facility cooling water intakes to minimise the potential risk of causing injury/mortality to marine fauna.
			
			The interaction of the vessels associated with the project with listed cetacean species will be consistent with the EPBC Regulations 2000 - Part 8 Division 8.1 Interacting with cetaceans (except in emergency conditions or when manoeuvring is not possible, such as in the case of pipelay activities), which include:
			• vessels will not knowingly travel > 6 knots within 300 m of a whale
			• vessels will not knowingly approach closer than 100 m to a whale
			• vessels will not knowingly restrict the path of cetaceans.
			
			Vessel speed restrictions will be implemented within the defined operational area of the gas export pipeline route, except where necessary to preserve the safety of human life at sea. This will be reinforced through training of selected vessel crew to sight and manage interactions with turtles.
			
			Personnel associated with vessel activities will be subject to project inductions which will address the requirements for vessel operators in relation to interactions with marine fauna.
			
			No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods.
				The potential impacts and risks associated with the physical presence of the project and vessels are considered broadly acceptable given:
				• The residual risk is considered low as:
				  • the controls outlined limit vessel speeds and therefore marine fauna interactions
				  • there are no regionally significant feeding, breeding or aggregation areas for marine fauna within the Barossa offshore development area
				  • installation activities for the gas export pipeline are of limited duration (6 –12 months)
				  • while the southern end of the gas export pipeline is located within internesting habitat critical to the survival of flatback and olive ridley turtles, installation activities will take into consideration seasonal presence/activity to mitigate potential impacts.
					Fixed offshore facilities/ infrastructure and equipment in the Barossa offshore development area will not be located in regionally important feeding and breeding/ nesting biologically important areas for marine mammals or marine reptiles.
					
					Vessel speeds restricted in defined operational areas within the project area, to reduce the risk of physical interactions between cetaceans/marine reptiles and project vessels.
					
					Zero incidents of injury/mortality of cetaceans/marine reptiles from collision with project vessels operating within the project area.
					
					No significant impacts to turtle populations from installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley turtles (April to August) in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	• EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. The key management measures meet the requirements of the EPBC Regulations 2000 – Part 8 Division 1 and the applicable management/recovery plans and conservation advices. • The project aligns with the applicable management/recovery plans and conservation advices. **Table 6-11** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.	

6.4.3 Seabed disturbance

The installation and placement of offshore facilities (including the MODU) and subsea infrastructure/equipment will directly contact the seafloor and will inevitably result in localised impact (direct and indirect) to seabed features and the benthic environment in the project area. The risk assessment for potential impacts is summarised in **Table 6-13**. Similarly, decommissioning activities will result in localised seabed disturbance. However, as outlined in **Section 4.3.4**, the activity-specific decommissioning EP will provide detailed information and descriptions of the nature and scale of the activity, potential environmental impacts and risks, and the control measures that will be implemented. An overview of possible decommissioning interactions and impacts have been considered within the context of the impact assessment summarised in this section, as appropriate at this early stage of development planning.

Table 6-13: Seabed disturbance risk assessment

Risk	Seabed disturbance due to the installation, placement and decommissioning of offshore facilities (including the MODU) and subsea infrastructure/equipment.		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor		
Key project stage	Development drilling Subsea installation (including the gas export pipeline) Operations Decommissioning		
Key factor(s) (see Table 6-7)	Physical environment (seabed features) Shoals and banks Marine reptiles	AMPs KEFs	
Other relevant factor(s) (see Table 6-7)	N/A		
Potential impact(s)	• Direct or indirect (i.e. sedimentation and turbidity) loss of benthic habitat. • Change in marine turtle behaviour/movements. • Physical damage and/or disturbance to unique seafloor KEFs. • Physical damage and/or disturbance to benthic habitat (not unique) within the • Oceanic Shoals marine park and to shoals/banks.		
Risk assessment			
Barossa offshore development area			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	2 Minor (Bio)	2 Remote	4 Low
Residual risk	2 Minor (Bio)	2 Remote	4 Low
Gas export pipeline corridor			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	3 Moderate (Bio)	3 Rare	9 Medium
Residual risk	3 Moderate (Bio)	3 Rare	9 Medium
Confidence	Barossa offshore development area – high Gas export pipeline corridor – medium (and to be informed by further route optimisation surveys)		

Impact assessment and risk evaluation

The offshore facilities, in-field subsea infrastructure/equipment and gas export pipeline will necessarily interact with the seabed and cause direct physical disturbance to seabed features and the benthic environment. Direct physical disturbance is associated with key project facilities/infrastructure, mooring/anchoring and installation activities (e.g. direct disturbance footprint from seabed intervention techniques and physical placement of any excavated materials directly on the seabed; refer to **Section 4.3.5.2** for description of direct seabed disturbance footprint and **Section 4.4.3** for a description of the alternative seabed intervention techniques). The extent of this direct disturbance is relatively small (in the order of approximately 107 ha (1.07 km^2)) at a regional scale.

While not directly related to the installation and placement of offshore facilities and subsea infrastructure/equipment, the planned discharge of drill cuttings and fluids during drilling of the development wells will result in some seabed disturbance. Detailed discussion of potential impacts to the seabed associated with the planned discharge of drill cuttings and fluids is provided in **Section 6.4.8.2**. In summary, a localised drill cuttings pile is expected to occur in the immediate vicinity of each development well, with most of the sediment deposited within several hundred metres of the release location.

Indirect and temporary seabed disturbance may occur as a result of sedimentation and turbidity generated from activities associated with the controlled placement of infrastructure on the seabed or from seabed intervention techniques used during installation activities (noting that trenching/dredging may only be required if the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, refer to **Figure 4-12**).

As outlined in **Section 4.3.5.2**, disturbance associated with the localised lateral movement or scouring of the gas export pipeline may occur in cyclonic and storm events. However, based on observations of other pipelines in the region, it is expected that the pipeline will become partially buried which provides further stabilisation in storm events. At this early stage of the project, it is assumed that direct disturbance will be limited and within design specifications that accommodate lateral movement. Detailed design studies will be undertaken as the engineering progresses to understand how the gas export pipeline would behave in cyclone/storm conditions. Further assessment of seabed disturbance associated with the potential movement of the gas export pipeline will be included in the activity-specific EP.

As discussed in **Section 4.3**, a fibre optic cable connection between the Barossa offshore development area and Darwin may be installed. The cable route is still subject to refinement and will be influenced by future financial and commercial arrangements and the timing of other customer negotiations and connections. However, given the early stage of the project and the small, linear nature of any disturbance associated with the installation of a fibre optic cable, the risks of seabed disturbance from this activity are considered to be significantly less than those for pipeline installation and thus broadly assessed within this OPP. Activity specific secondary approvals will be obtained in accordance with regulatory requirements at the time commercial arrangements are agreed.

Direct impacts

Benthic habitats (including those within the KEFs and Oceanic Shoals marine park)

Based on available information, including the bathymetry and seabed topography data derived from previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across the area (refer **Section 5.2**), the Barossa offshore development area does not contain any significant or unique areas of benthic habitat and is situated on a plain comprising of relatively homogenous flat, soft sediments. In general, the infauna and macrofauna communities and benthic habitat in the Barossa offshore development area and northern end of the gas export pipeline are known to be uniform, widespread and consistent with that associated with deep water environments elsewhere in the region and are representative of the broader Bonaparte Basin and Timor Sea (**Section 5.5.2**).

The seabed along the gas export pipeline is likely to vary from relatively smooth and gentle slopes at the northern end to irregular at the southern end as a result of various seabed channels and ridges. Marine sediments within the gas export pipeline corridor are likely to comprise of fine to medium sands/silt and clay in the northern end, with cemented sediments (i.e. rock/reef outcrops) occurring in the southern end. From results of studies undertaken by AIMS, benthic habitats within the gas export pipeline corridor are expected to consist of predominantly burrowers/crinoids (approximately 12%), filter feeders (approximately 7%), macroalgae (approximately 5%), with a substantial portion of the area also supporting no benthic habitat (approximately 81%) (**Section 5.5.2.2**). No significant or restricted areas of benthic habitat are known to occur.

The Barossa offshore development area and northern end of the gas export pipeline occur within a portion of the KEF of the shelf break and slope of the Arafura Shelf, with a portion of the export pipeline corridor also passing through the carbonate bank and terrace system of the Van Diemen Rise (**Figure 5-20**). These KEFs are recognised as unique seafloor features with ecological properties of regional significance (**Section 5.7.8**). While the seabed in the Barossa offshore development area and northern end of the gas export pipeline corridor are characteristic of the continental slope, no unique features of ecological significance associated with the values and sensitivities of the shelf break and slope of the Arafura Shelf KEF, such as patch reefs and hard substrate pinnacles, were observed during the Barossa marine studies program, nor are these topographically distinct features evident from the bathymetry data derived from multiple seismic, geophysical and bathymetric surveys undertaken across this area. However, were these features to occur, the project would result in disturbance of approximately < 0.007% of the seabed within this KEF and thus not result in a significant impact to the ecological values associated with these seabed features. The KEF of the shelf break and slope of the Arafura Shelf is approximately 75 km away from the shallow water area of the pipeline corridor immediately east of the Oceanic Shoals marine park, and therefore no secondary stabilisation such as trenching/dredging, or pipelay vessel anchoring, will occur within this KEF.

The seafloor features characteristic of the carbonate bank and terrace system of the Van Diemen Rise KEF, such as hard substrate terraces and banks, ridges, valleys and pinnacles, were observed in the southern end of the gas export pipeline corridor. However, the refined gas export pipeline corridor seeks to minimise, where practicable, areas of seabed within the corridor that are associated with the seafloor features/values of the KEF, and also minimise seabed intervention and stabilisation required. The seabed footprint that would be directly affected by the installation and physical presence of the pipeline only represents a very small portion of the KEF (< 0.0002%), which covers an area of approximately 31,278 km^2. The Van Diemen Rise KEF is greater than 18 km from the shallow water area of the pipeline corridor immediately east of the Oceanic Shoals marine park, and therefore no secondary stabilisation such as trenching/dredging, or pipelay vessel anchoring, will occur within this KEF. Therefore, it is highly unlikely that the physical presence of the project will result in a significant impact to the ecological values associated with these seabed features.

The gas export pipeline corridor overlaps approximately 708 km^2 (approximately 1%) of the Oceanic Shoals marine park. Benthic habitats within the portion of the marine park overlapped by the pipeline corridor are representative of those within the broader marine park boundary. Benthic habitats within the portion of the marine park overlapping the gas export pipeline corridor are characterised predominantly by abiotic areas that support no benthic habitat, filter feeders, burrowers/crinoids and small areas of corals and macroalgae (**Figure 5-9**; Heyward et al. 2017). This profile is consistent with the broader marine park where benthic habitats are similarly characterised predominantly by filter feeders, burrowers/crinoids and abiotic areas that support no benthic habitat (**Figure 5-9**; Heyward et al. 2017). Other benthic habitats present include small areas supporting hard corals, gorgonians, alcynon and Halimeda. It is important to note the area of seabed directly disturbed by the gas export pipeline within the Oceanic Shoals marine park would be significantly smaller than the area covered by the corridor (approximately 0.0002% of the marine park). Therefore, it is highly unlikely that the physical presence of the gas export pipeline will result in a significant impact to the ecological values associated with the marine park.

While ConocoPhillips continues to undertake further surveys and engineering studies, routing a portion of the pipeline through the western part of the corridor within the marine park could provide the most acceptable environmental outcome. For example, it would remove the need for extensive seabed intervention works including secondary stabilisation such as trenching and dredging (as defined in **Section 4.3.5.2**) (refer to discussion below under indirect impacts), and increase the distance between pipeline installation activities and the Tiwi Islands (including the high density nesting beaches for olive ridley turtles on the north-west coast of the Tiwi Islands). Refer to **Section 4.3.3.2** for further discussion of the key design and engineering considerations that need to be taken into account in the gas export pipeline route selection process.

Overall, the seabed disturbance resulting from the installation and placement of offshore facilities and subsea infrastructure/equipment (including the gas export pipeline) is expected to cause very localised disturbance of benthic habitats and short-term changes to invertebrate communities in the immediate vicinity (within tens of metres) of seabed infrastructure. The risk to benthic habitats, including those associated with the KEFs and Oceanic Shoals marine park, in the Barossa offshore development area from seabed disturbance is considered low. Trenching/dredging activities and anchoring of the pipelay vessel may only be required if the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor (**Figure 4-12**). The residual risk associated with seabed disturbance in the gas export pipeline corridor has been assessed as medium to reflect the medium confidence assessed at the time of the risk reviews and recognising that further studies are planned in order to inform further definition of the gas export pipeline route.

Refer to **Section 4.3.3.1** for the context of the in-field infrastructure proposed in the immediate locale of the development. Furthermore, considering the very small size of the project footprint (in the order of 1.07 km^2) significant impacts to the regional seabed profile across the Bonaparte Basin are highly unlikely. In terms of the recolonisation and rehabilitation of benthic communities disturbed by the project, the experience of other similar offshore developments showed that soft-sediment benthic communities were observed to recover within 12 months following the installation of Woodside's pipeline in Mermaid Sound (WA), and hard corals were expected to recover within a few years of the installation of the Ichthys gas export pipeline (INPEX 2010).

Marine fauna

Disturbance of the seabed is not anticipated to significantly affect mobile marine fauna, such as marine mammals, marine reptiles, fish and sharks/rays. The majority of these species are generally present within the water column and are not solely reliant on benthic habitat (**Section 5.6**). The area of seabed to be disturbed within the project area also represents a very small portion of the habitat available for these species. For example, the gas export pipeline corridor overlaps 1,192 km^2 (3.7%) and 255 km2 (3.2%) of internesting habitat critical to the survival of flatback turtles and olive ridley turtles, respectively, in which individuals may rest on the seabed between nesting events. However, the actual area of seabed within the internesting area directly disturbed by the gas export pipeline will be significantly smaller, in the order of approximately < 0.0001% for flatback turtles and approximately < 0.0015% for olive ridley turtles (including the potential requirement for trenching/dredging and pipelay vessel anchoring if the final pipeline route remains outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor where it overlaps with habitat critical to the survival of flatback turtles, refer to **Figure 5-18**). Taking into account the outcomes of a professional review by Pendoley (2017; **Appendix Q**), as well as a number of other studies investigating internesting behaviours of flatback and olive ridley turtles (**Section 5.6.3**), the 30 m depth contour is considered to encompass the vast majority of the area within which flatback and olive ridley turtles would undertake internesting activities (i.e. resting on the seabed), with the existing 24 nm (44.5 km) Contiguous Zone Boundary encompassing the extent (waters up to 55 m deep) that internesting turtles are likely to extend to (Pendoley 2017). These studies have demonstrated that while turtles may be present in offshore waters with water depths of up 55 m during the internesting period, they are typically freely moving through these areas before they return to shallow waters (less than 30 m deep and typically shallower than 10 m) to rest in the days leading up to re-nesting activity.

If the final pipeline route is located within the Oceanic Shoals marine park (i.e. not within the shallow water area), the gas export pipeline would not intersect areas in which internesting behaviours occur (i.e. resting in waters less than 30 m deep prior to re-nesting) as the minimum water depths of the corridor (excluding the shallow water area) where it overlaps internesting habitat critical to the survival of marine turtles are > 30 m deep. The broader area that is traversed by internesting turtles (i.e. waters up to 55 m deep) occupies a portion of the gas export pipeline corridor, with the vast majority of suitable internesting habitat remaining outside the corridor and available for internesting turtles.

If the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, this section of the pipeline corridor does not overlap habitat critical to the survival of olive ridley turtles, but does overlap the habitat critical to the survival of flatback turtles. This shallow water area of the pipeline corridor (where trenching/dredging and pipelay vessel anchoring may be required) only represents 0.15% of the habitat critical to survival for flatback turtles and the area is greater than 20 km form the Tiwi Islands coastline (**Figure 5-18**). While some internesting turtles are known to move away from nesting beaches between laying clutches, potentially moving considerable distances between nesting events, many turtles are likely to remain near to their nesting beaches, and as they leave beaches they typically spread out and consequently, density decreases rapidly with increasing distance from a nesting beach (Waayers et al. 2011, Whittock et al. 2014). Additionally, potential internesting habitat less than 30 m deep is widespread in the immediate vicinity (**Figure 5-18**) and trenching/dredging activities will not occur during the peak internesting season for either flatback or olive ridley turtles (April to September). Therefore, even if a marine turtle was to move from the immediate location of an activity, there is widespread internesting habitat available in the immediate vicinity that marine turtles could continue to use within the identified habitat critical and the potential impacts are not expected to impact biologically important behaviours or prevent those behaviours from occurring.

Additionally, although some loss of marine turtle foraging habitat is likely to occur as a result of the installation of the gas export pipeline on the seabed, such foraging habitat is widely represented in the region and any loss is expected to be negligible. Environmental, geophysical and bathymetric surveys have not indicated the presence of any unique or limiting benthic foraging habitat for marine turtles within the gas export pipeline corridor. Therefore, the physical presence of the gas export pipeline is not expected to adversely impact on biologically important behaviours or biologically important habitat, including habitat critical to the survival of marine turtles.

The gas export pipeline corridor does not transect the known significant seagrass sites for dugongs in the vicinity of the Tiwi Islands (**Figure 5-17**).

The presence of the pipeline infrastructure has the potential to provide a beneficial impact over time with creation of hard substrate for the settlement, growth and colonisation by marine flora and fauna assemblages, including for fish communities and other marine fauna.

Commercial and traditional fishing

The direct disturbance to the seabed by the facilities/equipment in the Barossa offshore development area and the gas export pipeline is not predicted to negatively affect the catchability of species targeted by commercial or traditional Indigenous fishers, given the small nature of the disturbance in the context of the fishing areas available (**Section 5.7.12** and **Section 5.7.13**).

Indirect impacts

Barossa offshore development area

Indirect impacts associated with a temporary (several hours) and localised (within tens of metres) decline in water quality due to increased suspended sediments or sedimentation of the seabed are not expected to affect any key values and sensitivities of regional importance. The controlled placement or routine operational maintenance of infrastructure on the seabed will result in a single brief disturbance resulting in a transient plume of sediment. The amount of sediment suspended will be proportional to the volume/weight of the structure and 'rate' (i.e. force) at which is it placed on the seabed. Considering that placement of subsea equipment/infrastructure will be via a controlled, slow descent, and that the interaction of maintenance activities with the seabed is expected to be very localised and minor in nature, most of the sediments are likely to settle out within close proximity of the area disturbed (within tens of metres). While some of the finer sediments may travel greater distances (within hundreds of metres) they are highly unlikely to contact the nearest shoals/banks given the long distance to these features (a minimum distance of 27 km).

Given the temporary, reversible and small-scale nature of any increase in turbidity and sedimentation and associated habitat loss, and the nature of benthic communities known to occur in the Barossa offshore development area (as described above; uniform, widespread and consistent with that associated with deep water environments elsewhere in the region see **Figure 5-6** and **Section 5.5.2**), significant impacts are considered highly unlikely.

Gas export pipeline installation – seabed intervention works and pipelay activities

Seabed intervention techniques for the gas export pipeline (for example free-span infrastructure, concrete mattresses and sand bags, rock bolting, and secondary stabilisation such as trenching/dredging or rock dumping) and the use of an anchored pipelay vessel during the installation of the gas export pipeline are dependent on the future selection of a pipeline route within the corridor and the resultant level of intervention required. Such activities may create a sediment plume during the project as the seabed may be actively disturbed.

Pipelay vessel anchoring (which may only be required if the pipeline remains outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, Section 4.3.3.2) will likely result in brief disturbance events and a small, localised sediment plume from anchor and chain placement on the seabed each time the anchor is moved. The stabilisation techniques of free-span infrastructure and sand bags are likely to result in a single brief disturbance associated with the placement of these on the seabed, with the resulting transient sediment plume being temporary (several hours) and localised, as described above. More extensive secondary stabilisation works such as trenching/dredging (which may only be required if the pipeline remains outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, **Section 4.3.3.2**), will likely result in a larger sediment plume. The area affected by the resulting sediment plume will be influenced by the volume of materials disturbed, the rate of sediments released into the water column, the particle sizes and current speeds. It is expected that any re-mobilisation of excavated sediments will have similar resultant impacts and risks.

Review of relevant turbidity surveys/studies

To inform this impact assessment, a review of other similar seabed intervention techniques and their effects was undertaken as relevant to this project context of a linear pipeline installation in nearshore waters. This is summarised in the following paragraphs for context.

A turbidity survey undertaken for Chevron's Wheatstone project in the Pilbara (WA) recorded turbidity levels during pipeline trenching operations, using a mechanical trenching machine, offshore from Onslow (water depths of 130 m–150 m). The survey recorded average turbidity levels within 50 m of the trench area of approximately 15 Formazin Turbidity Units (FTU), which was 10 FTU above the maximum recorded background turbidity (5 FTU) (Chevron 2014a). Peak turbidity levels of > 80 Formazin Turbidity Units (FTU) were also recorded within 50 m of the trench area. Based on the survey, it was concluded that a turbid plume may be evident up to 70 m from trenching operations depending on environmental conditions (Chevron 2014a). However, within two hours of ceasing trenching operations, the turbidity level was observed to return to, or very close to, background levels (Chevron Australia 2010i, 2010j, cited in Chevron 2014a).

Modelling was undertaken for Chevron's Gorgon project for nearshore trenching operations, which were within approximately 11 km of the WA coastline and in water depths of 1 m–8 m (Chevron 2014b). These nearshore, shallow waters were noted as having naturally turbid conditions due to their close proximity to the mainland coast. The water depths and background turbidity conditions are expected to be broadly similar to those in the Barossa gas export pipeline corridor where extensive seabed intervention works may be required (**Section 4.3.3.2**). The modelling results showed sediment concentrations of 10 mg/L above background were limited to within 2 km of a pipeline trench, with the relatively low mobilisation rate of the excavator (Chevron 2014b). It was noted that suspended and resuspended particles in the water column accumulated as excavating continued, as a result of the nearshore sediments consisting of fine particles (APASA 2010, cited in Chevron 2014b). Modelling also showed that sediment concentrations of 2 mg/L above background levels only occurred for 1–2 days throughout trenching activities (Chevron 2014b).

Considering the result of the Chevron survey and modelling (as discussed above), and the relatively short distance over which trenching/dredging operations in the gas export pipeline may be required (i.e. sections within the 30 km long shallow water area east of the Oceanic Shoals marine park), it is anticipated that the area adjacent to the pipeline will experience a short-term (several hours to days at any given point) temporary but reversible increase in localised turbidity.

The Macedon gas project involved the installation of a subsea pipeline from the offshore Macedon gas field (approximately 100 km west of Onslow, WA) to onshore facilities. Geotechnical surveys undertaken during the FEED stage of the project identified that seabed intervention works, such as trenching, rock dumping and rock bolting, would be required for a portion of the pipeline (BHP Billiton 2010a). Approximately 9 km was expected to be continuously trenched in nearshore waters (< 10 m deep) with an additional 34 km of the route proposed to be stabilised by plowing and rock dumping (or rock bolting) (10 m–50 m water depths). For the pipelay installation activities conservative separation buffers were applied to provide protection from indirect impacts due to turbidity from the pipelay activities. A 700 m buffer was applied to primary features (e.g. islands and fringing reef platforms, and named reefs) and a 600 m buffer applied to secondary features (e.g. shallows associated with limestone platforms and typically sheltered by islands that are likely to support benthic communities, and isolated peak features such as reefs and bommies that generally support corals) (BHP Billiton 2010a; Environmental Protection Authority (EPA) 2010). Separation buffers (200 m for primary features and 100 m for secondary features) were also applied for vessel movement/anchoring to allow for short term pulses of turbidity associated with these activities (EPA 2010). As detailed in the compliance reporting (BHP Billiton 2016), impacts were consistent with the conclusions made in the EIS with regards to the extent/severity and duration, i.e. the marine pipeline separation distances were effective at limiting benthic primary producer habitat loss (defined as recoverable within 5 years) to less than 1%.

Turbidity measurements collected during the construction of a subsea pipeline from Pallarenda Beach to Magnetic Island through the Great Barrier Reef reported turbidity levels were within 5 NTU of background levels at 300 m from the construction area (Great Barrier Reef Marine Park Authority 2009, cited in BHP Billiton Petroleum 2010b). Construction activities included the use of backhoes and excavators in intertidal areas, a lay barge for subtidal pipelay and jetting. The sediments in the vicinity of Magnetic Island consisted of silty clay sea floor, which are considered broadly comparable to those expected within the majority of the gas export pipeline corridor. BHP Billiton Petroleum (2010b) also noted that jetting of fine sediments did not have the potential to create a persistent turbidity plume at any given location as there was no mass movement of sediment. In addition, the point of the generation of the plume and the plume itself would move with the jetting location (BHP Billiton Petroleum 2010b). Modelling undertaken for the installation of the offshore pipeline for Chevron's Gorgon project did not record any significant turbidity plumes from jetting of offshore sections along the pipeline route (water depths between 6 m and 16 m) (Chevron 2014b). However, in the shallow water depths (1 m–8 m) the mobilisation of sediments by jetting was predicted to result in a turbidity plume, with concentrations of 25 mg/L above background limited to approximately 5 km from the pipeline route (Chevron 2014b).

Sediment plume dispersion modelling undertaken to assess potential impacts to benthic habitats from the installation of the trunkline in nearshore waters (up to 37 km from the WA coastline, between water depths of approximately 10 m–50 m) (via trenching (dredging) and backfill) for Chevron's Wheatstone project predicted the activity would generate average suspended sediment concentrations of generally 1–3 mg/L (Chevron 2014c). The 'zone of influence'[4] was predicted to extend up to 10 km from the trench alignment in some circumstances, with the direction of the plume influenced by local climate conditions (Chevron 2014c). It was noted that the sediment plumes affecting a particular area were likely to be short-term in duration as trenching activities along the route were expected to move at a rate of approximately 150 m–200 m per day (Chevron 2010).

Benthic habitats (including those within the KEFs and Oceanic Shoals marine park)

Based on the AIMS extended benthic habitat model (**Figure 5-9**), benthic communities that may occur within the area influenced by a temporary increase in sedimentation/turbidity (both within the water column and at the seabed) are likely to be predominantly filter feeders and abiotic areas that support no benthic habitat with small areas of macroalgae and corals, gorgonians, alcynon and Halimeda (**Figure 5-9**).

Filter feeders may exhibit a range of physiological responses to acute and chronic sediment stress, including elevated respiration, pore closure, tissue retraction, changes in morphology, bleaching, mortality and increased instances of disease (Schönberg 2016). In general, studies have found that potential impacts are greater with increasing sediment concentration, duration and frequency; more pronounced for finer and more terrestrial (siliciclastic) sediment than for coarser and more biogenic (carbonate) sediments; and more significant for the larval/juvenile stages than the adult populations (Schönberg 2016).

Some species of filter feeders are able to cope with moderate sediment stress based on their growth form and use of passive or active cleaning mechanisms. Schönberg (2016) notes that some species within filter feeding communities have adapted to more turbid/sediment environments and therefore may persist at dredging sites. Species which display special adaptations include endopsammic sponges (living partially buried within sediments), species that are fast growing with morphological plasticity, erect growth forms and growth forms with exhalant openings on apical body parts. Filter feeders that are able of keeping their surfaces sediment-free are also more likely to be resilient to increased sedimentation and turbidity (Schönberg 2016).

Macroalgal abundance and community composition in coastal areas is known to be influenced by sedimentation. A study by Eriksson and Johansson (2005) investigating the long term effects of natural sediment deposition on the development of a macroalgal community over several growing seasons observed that macroalgae cover and density increased when the process of natural sediment deposition was removed. However, the study observed that responses were species-specific, for example species of ephemeral green algae were highly tolerant to sedimentation while belt-forming perennial brown algae were less so. The study also noted that vegetative propagation and dispersal by fragmentation was common in the study area and suggested this response allowed these species to tolerate sedimentation (Eriksson and Johansson 2005).

A comprehensive review of the effects (direct and indirect) of sedimentation/turbidity on corals concluded the key proximal stressors associated with these activities were reduced light attenuation affecting photosynthesis, high suspended sediment concentrations affecting feeding processes and sediment deposition causing smothering and restriction of solute exchange and light (Jones et al. 2017). A study by Curtin University suggests that inshore corals may be more resilient to natural and human-induced sediment and resuspension events than previously thought (Browne et al. 2015). The study subjected three species of coral to two exposure regimes: pulsed turbidity events for four weeks followed by two months of recovery (constant regime) or pulsed turbidity events every other week followed by one month of recovery (periodic regime). The study observed that the periodic exposure regime was less detrimental to all coral species than the constant exposure regime, as shown by elevated yields and lower tissue morality rates (Browne et al. 2015). Little to no change in coral health was observed following one month of moderate sediment exposure. However, respirations rates increased and photosynthesis rates declined when exposed to extreme sediment levels suggesting coral stress and reduced health. At extreme sedimentation levels (65 mg cm^{-2} per day, with an average turbidity of 90 mg/L), species morphological differences were considered to be key determinants of coral survival. For example, the more sensitive foliose corals showed tissue death of up to 17% at extreme sediment levels while no necrosis was observed in the massive (boulder-shaped) coral species and only limited declines in photosynthetic yield (Browne et al. 2015). The nearshore waters to the north of the Tiwi Islands support a known significant seagrass site for dugongs (**Figure 5-17**). Seagrasses are known to be sensitive to natural and anthropogenic sedimentation disturbances. However, many species have the ability to recover from disturbance within relatively short time frames; typically in the order of several months (Vanderklift et al. 2017). The loss and recovery of seagrass over relatively short time periods (months to years) has been observed as a natural phenomenon and reflects changes in environmental variables (e.g. temperature, light and salinity), natural disturbances (storms/cyclones) and potentially grazing patterns of herbivores (Vanderklift et al. 2017). Considering the observations by Heyward et al. (2017), the nearshore waters and shelf areas in the vicinity of the Tiwi Islands are expected to be characterised by naturally turbid conditions due to strong tidally driven currents interacting with the seabed ridges and valleys. Therefore, it is expected that benthic communities in these areas have a natural resilience to higher sediment levels, turbid conditions and reduced light attenuation.

[4] Defined by Chevron (2014c) as the area that may be influenced by the dredge plume at low levels (for example sub-lethal impacts on key receptors, turbidity may be visible or very light sedimentation may occur) but this is predicted to be unlikely to have any material and/or measurable impact on the key receptors.

This conclusion is supported by the various studies discussed above. Some of the shoals/banks, such as Shepparton Shoal, Marie Shoal and Goodrich Bank, in close proximity to the gas export pipeline corridor (**Figure 5-11**) may be temporarily affected by increased sediment levels. These shoals/banks support a range of benthic communities, including algae, corals and filter feeders. Considering the expected short duration of increased sedimentation at any one area, and that benthic habitats in these areas are likely to have a natural resilience to higher sediment/turbid conditions, significant impacts are considered unlikely.

Marine fauna

There is potential for a small portion of internesting habitat critical to the survival of flatback and olive ridley turtles, and the internesting BIA for olive ridley turtles to be affected by increased sedimentation/turbidity as seabed intervention works for the gas export pipeline may be required within the internesting habitat critical to the survival of these species and adjacent to the internesting BIA for olive ridley turtles. The potential loss or reduction in quality of habitat may temporarily reduce available foraging and internesting habitats available for marine turtles. In the context of indirect impacts, potential marine turtle habitat may be temporarily lost indirectly through an increase in localised turbidity in the water column.

There is likely to be temporary indirect impacts on potential foraging habitat in the immediate vicinity of the pipeline installation activities. The majority of the benthic habitats within the pipeline corridor are expected to be characterised by filter feeders and burrowers/crinoids, with a substantial portion of the area supporting no benthic habitat (as summarised previously in **Section 5.5.2.2**). These habitats are well represented elsewhere within the region, with foraging grounds for flatback and olive ridley turtles represented across the wider Timor Sea (**Figure 5-18**). The area that may be indirectly affected is also not known to support biologically important foraging grounds for flatback or olive ridley turtles (**Figure 5-18**). Environmental, geophysical and bathymetric surveys have not indicated the presence of any unique or limiting benthic foraging habitat for marine turtles within the gas export pipeline corridor, including within the shallow water area to the east of the Oceanic Shoals marine park where secondary stabilisation, such as trenching/dredging and pipelay vessel anchoring, may be required. In addition, the area has naturally high levels of turbidity and periodic severe events associated with cyclones, demonstrating that local habitats are able to persist in a high turbidity environment.

Flatback and olive ridley turtles are known to naturally feed in turbid, shallow inshore waters. It is expected that sedimentation effects from seabed intervention activities will be localised in extent, commensurate with the nature of specific method(s) that will be further assessed as part of activity-specific EPs. In summary, there may be a temporary, localised, indirect impacts on flatback and olive ridley turtles associated with the loss of benthos, resulting in a negligible, temporary reduction in foraging habitat. However, individual turtles are expected to simply move to similar habitats that are well represented in the region, with no significant population level impacts predicted. Therefore, indirect impacts to foraging habitat are not expected to adversely impact on biologically important behaviours or habitat critical to the survival of marine turtles.

Internesting habitat in the immediate vicinity of the pipeline installation activities may be impacted by sedimentation/turbidity, however, the potential impact is considered low due to the restricted spatial extent that could be impacted by sedimentation/turbidity and as other significant areas for internesting occur beyond the gas export pipeline corridor (**Figure 5-18**), i.e. the corridor only overlaps 3.7% and 3.2% of the internesting habitat critical to the survival of flatback and olive ridley turtles, respectively. Drawing on the comparable case studies described earlier in this section for similar pipeline intervention activities, the area of local disturbance may be expected to be in the order of several hundred metres (e.g. as described for the Macedon project, with separation buffer of up to 700 m from primary features) to several kilometres (e.g. as observed for Gorgon nearshore trenching, with elevated turbidity observed within 2 km), depending on the nature of the activities and local seabed and oceanographic conditions at the time.

Geophysical and bathymetric survey data have indicated that secondary stabilisation, such as trenching/dredging, is not required in the portion of the gas export pipeline corridor that overlaps the internesting habitat critical to the survival of flatback and olive ridley turtles where water depths are greater than 30 m deep. Seabed intervention techniques are expected to be limited to span rectifications using concrete mattresses or grout bags, and rock berms. Therefore, for the majority of the pipeline corridor (with the exception of the shallow water area to the east of the Oceanic Shoals marine park – see discussion below) any indirect impacts within the internesting habitat critical to the survival of flatback and olive ridley turtles are likely to be localised and temporary in nature (lasting a matter of days), and would not significantly reduce the amount of available habitat.

The portion of internesting habitat critical to the survival of olive ridley turtles that is intersected by the gas export pipeline corridor is located off the west and south-west coast of Bathurst Island, where olive ridley turtles are known to nest only in low density numbers (Whiting et al. 2007a; Chatto and Baker 2008). This area is distant from the high density nesting beaches on the north-west coast of Melville Island. Additionally, the pipeline corridor is located in water depths > 30 m where it overlaps with the internesting habitat critical to the survival of olive ridley turtles. As described above, studies have demonstrated that while turtles may be present in offshore waters with water depths of up to 55 m during the internesting period, they are typically freely moving through these areas before they return to shallow waters (less than 30 m deep and typically shallower than 10 m) to rest in the days leading up to re-nesting activity. It is therefore expected that internesting olive ridley turtles would only be transiting within, or in the vicinity of, the gas export pipeline corridor in very low numbers. The gas export pipeline corridor overlaps only approximately 3.2% of the internesting habitat critical to the survival of olive ridley turtles, therefore, even if a marine turtle was to move from the immediate location of an activity, there is widespread internesting habitat available in the immediate vicinity that marine turtles could continue to use within the identified habitat critical and the potential impacts are not expected to impact biologically important behaviours or prevent those behaviours from occurring. Installation activities, including seabed intervention techniques, are expected to take approximately one to two months to complete for this portion of the pipeline, indicating that any indirect impacts to internesting habitat critical to the survival of olive ridley turtles would be short-term and temporary in nature.

If the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, then secondary stabilisation techniques such as trenching/dredging, and an anchored pipelay vessel, may be required. Given the shallow water area of the pipeline corridor which overlaps habitat critical to the survival of flatback turtles (approximately 0.15%), has some areas where water depth is < 30 m, it may be used by internesting flatback turtles in the days prior to re-nesting. The area of potential indirect impacts is expected to range from highly localised (for vessel anchoring) to between several hundred metres (e.g. as described for the Macedon project, with separation buffer of up to 700 m from primary features) to several kilometres (e.g. as observed for Gorgon nearshore trenching, with elevated turbidity observed within 2 km) for trenching/dredging activities. However, trenching/dredging activities would only occur outside of the peak internesting period for both olive ridley and flatback turtles (April to September). As described above, although internesting turtles are known to move away from nesting beaches between laying clutches, potentially moving considerable distances between nesting events, many turtles are likely to remain near to their nesting beaches, and as they leave beaches they typically spread out and consequently, density decreases rapidly with increasing distance from a nesting beach (Waayers et al. 2011, Whittock et al. 2014). Additionally, potential internesting habitat less than 30 m deep is widespread in the area (**Figure 5-18**). Installation activities, including seabed intervention techniques, are expected to take approximately three to six months to complete if the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, indicating that any indirect impacts to internesting habitat critical to the survival of flatback and olive ridley turtles as a result of secondary stabilisation and pipelay vessel anchoring would be short-term and temporary in nature.

Turtles are not deemed to be physiologically affected by an increase in suspended sediments associated with sediment-generating activities (DSD 2010). As part of the INPEX Ichthys project nearshore environmental monitoring program, an analysis of observed patterns of distribution and abundance of turtles and dugongs around Darwin Harbour and surrounding nearshore waters before and after dredging operations concluded that, *"…while spatial and temporal variation has been observed in the distribution and abundance of turtles and dugongs over the duration of the program, on the balance of evidence these differences appear most likely due to natural variation. As such, following the completion of the Dredging Phase of monitoring, there is no indication of any major changes to turtle or dugong populations in the Darwin region as a result of dredging activities"* (Cardno 2014). This observation supports the impact conclusion that population level impacts are not expected, including if dredging were required in the event that the final pipeline route is located outside (to the east) of the Oceanic Shoals marine park.

Any potential indirect impacts to internesting habitat critical to the survival of flatback and olive ridley turtles, the internesting BIAs for flatback and olive ridley turtles and/or to internesting females, are expected to be short term at any one area and localised, with only a small number of individuals being affected and the potential to impact nesting behaviour is also considered low. Therefore, indirect impacts from gas export pipeline installation activities within the internesting habitat critical to the survival of flatback and olive ridley turtles, including secondary stabilisation techniques and pipelay vessel anchoring (if the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area of the pipeline corridor), will not prevent any biologically important behaviours for marine turtles from occurring.

To further address potential impacts and risks to the marine environment associated with installation of the gas export pipeline, further engineering and field studies will be undertaken as the project design progresses. Detailed management controls to address sedimentation/turbidity will also be further evaluated and defined as part of the development and implementation of the gas export pipeline installation EP.

Decommissioning

Considering that the project is in the early design phase, and given the expected life of the project is approximately 25 years, it is premature to define a decommissioning strategy that aims to address environmental impacts in detail in this OPP. Indirect impacts arising from decommissioning activities at the end of the field life are expected to be broadly comparable with that generated from installation activities, as discussed above. As described in **Section 4.3.4**, seabed disturbance is considered a key decommissioning risk and therefore typical impacts from decommissioning activities have been summarised below for this aspect.

Direct physical disturbance to the seabed from decommissioning activities will be predominantly localised within the immediate vicinity of the project infrastructure. In addition, decommissioning activities may cause temporary and localised decline in water quality through sediment re-suspension, which has the potential to indirectly affect benthic communities and marine fauna within the immediate vicinity of the activity. Given the Barossa offshore development area does not support any sensitive benthic communities or aggregation areas for marine fauna it is unlikely that any temporary decline in water quality via increased sedimentation will result in a significant impact. The immediate area surrounding the pipeline corridor intersects with internesting habitat critical to the survival of flatback and olive ridley turtles and there are a number of shoals and banks that support benthic communities in close proximity to the corridor (e.g. Goodrich Bank, Marie Shoal and Shepparton Shoal). However, this area along the mid-shelf is typically highly turbid, as observed by AIMS during offshore surveys adjacent Goodrich Bank and Cape Helvetius (**Appendix F**), and any localised and temporary addition of sediment load to the water column from decommissioning the pipeline is unlikely to result in a long-term impact to these receptors.

A detailed EP specific to decommissioning activities will be prepared for review and acceptance towards the end of the field life for the Barossa project. At that time, a detailed evaluation of environmental risk and impacts associated with decommissioning will be undertaken, with practicable options assessed for ALARP and acceptability. A commitment to meet this forward process is reflected in **Section 7** of this OPP.

Impact and risk summary

In conclusion, the residual risk of impact to the physical environment, benthic habitats, shoals and banks, KEFs, Oceanic Shoals marine park and marine fauna from seabed disturbance is considered low given the relatively small nature of the direct disturbance footprint and the fact that the Barossa offshore development area does not contain seabed with areas of unique benthic habitat.

Taking the results of relevant studies and the gas export pipeline corridor into consideration, there is potential for some of the shoals/banks, seafloor features/values associated with the KEFs, a portion of internesting habitat critical to the survival of flatback and olive ridley turtles and the known significant seagrass sites for dugongs in the vicinity of the pipeline route to be affected by a sediment plume or increased turbidity — albeit short-term (in the order of days to several weeks). If the final pipeline route remains outside of the Oceanic Shoals marine park, i.e. in the shallow water area of the pipeline corridor, and if secondary stabilisation (trenching/dredging) is required, it would only occur outside of the peak internesting season for both flatback and olive ridley turtles (April to September).

As outlined in **Section 4.3.3.2**, the gas export pipeline corridor has been refined to minimise seabed intervention and stabilisation as much as practicable, however the final route is yet to be defined. The potential environmental impacts and risks associated with the activity will be assessed in further detail in the activity-specific EPs. However, the impact assessment presented in this OPP is considered to provide a conservative evaluation.

The project is considered consistent with the relevant requirements of the Recovery Plan for Marine Turtles in Australia and the Australian IUCN Reserve Management Principles as related to seabed disturbance (**Table 6-14**). A summary of the potential impacts, proposed key management controls, acceptability and EPOs for seabed disturbance are presented in **Table 6-15**.

Proposed key management controls, acceptability and EPOs for seabed disturbance as related to decommissioning activities, are summarised in **Table 7-1**.

Table 6-14: Summary of alignment with relevant EPBC management plans for seabed disturbance

Relevant factor	Relevant recovery plan/ conservation advice/ management plan	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Marine reptiles - Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (June 2017) (DoEE 2017a)	Manage infrastructure, coastal development and dredging to ensure ongoing biologically important behaviours for marine turtle stocks continue.	• The impacts from infrastructure placement and dredging on marine turtles will be managed through: ◦ the pipeline corridor has been refined through consideration of a range of criteria (refer to **Section 4.4.3**), including environmental criteria relevant to marine turtles by restricting the majority of the pipeline corridor to waters deeper than 30 m. Within the pipeline corridor, the only area of waters < 30 m deep is restricted to the 30 km of shallow water area east of the Oceanic Shoals marine park and this would only be used if the final pipeline route remains outside of the marine park. ◦ Flatback and olive ridley turtles within or in the vicinity of the gas export pipeline corridor in waters > 30 m deep are typically freely moving through these areas within the water column rather than requiring benthic habitat for internesting activities. ◦ while the shallow water area to the east of the Oceanic Shoals marine park overlaps the internesting habitat critical to the survival of flatback turtles, it only overlaps approximately 0.15% of the internesting habitat critical to the survival for flatback turtles and it does not overlap internesting habitat critical to the survival of olive ridley turtles. Additionally, potential internesting habitat is widespread in the surrounding area, with indirect impacts from trenching/dredging expected to be temporary in nature and potentially extend from several hundreds of metres to a few kilometres. Therefore, even if a marine turtle was to move from the immediate location of an activity, there is widespread internesting habitat available in the immediate vicinity that marine turtles could continue to use within the identified habitat critical and the potential impacts are not expected to impact biologically important behaviours or prevent those behaviours from occurring. ◦ as the physical presence of the gas export pipeline within internesting habitat critical to the survival of marine turtles has been minimised, i.e. approximately 0.0001% and 0.0015% of the internesting habitat critical to the survival of flatback and olive ridley turtles respectively, the physical presence of the gas export pipeline during operations is considered highly unlikely to impact the species' use of the area. ◦ further engineering and environmental studies to optimise the final pipeline route design with the aim of minimising seabed intervention methods where possible. • Significant behaviour modification as a result of habitat modification from dredging is not expected as: ◦ should dredging be required for the installation of the gas export pipeline, there may be some localised impacts, e.g. behaviour modification, in the immediate vicinity of the dredging activities. However, turtles are not deemed to be physiologically affected by an increase in suspended sediments associated with sediment-generating activities (DSD 2010), thus impacts are unlikely to impact biologically important behaviours or prevent those behaviours from occurring. • It is noted the description of the threat of habitat modification (dredging and trawling) in the recovery plan recommends that dredging and trawling activities in important internesting habitat should be undertaken outside peak nesting seasons. With regard to the project: ◦ dredging for pipeline installation may only be required in the shallow water area of the pipeline corridor (**Figure 4-12**) for a pipeline route outside of the Oceanic Shoals marine park. Should dredging be required for pipeline installation, dredging activities will occur outside the peak flatback turtle (June to September) and olive ridley (April to August) internesting period.

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)

			• although there is the potential for a portion of the internesting habitat critical to the survival of marine turtles to be exposed to indirect impacts, such as an increase in turbidity from dredging activities, the potential impact to flatback and olive ridley turtles is considered low, as:
			  • indirect impacts will be temporary and are only expected to extend from hundreds of meters to several kilometres from the dredging areainternesting habitat is expected to recover relatively quickly
			  • internesting habitat is expected to recover relatively quickly
			  • therefore, only a very small additional portion of the internesting area would be potentially exposed to indirect impacts
			  • turtles are not deemed to be physiologically affected by an increase in suspended sediments associated with sediment-generating activities (DSD 2010)
			  • trenching/dredging activities, if required, would only occur outside of the peak internesting periods for both flatback and olive ridley turtles and are unlikely to impact marine turtles resting in shallow waters in the days prior to re-nesting.
			
			It is concluded that the implementation of management controls will allow the activities to be managed to ensure that biologically important behaviour for marine turtle stocks continue.

		Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of the species.	• Given the majority of internesting turtles resting in the days prior to re-nesting are in waters <30 m, by restricting the majority of the pipeline corridor to waters deeper than 30 m, impacts from the pipeline are not expected. Within the pipeline corridor, the only area of waters < 30 m deep is restricted to the 30 km of shallow water area east of the Oceanic Shoals marine park if the final pipeline route remains outside of the marine park. • Flatback and olive ridley turtles within or in the vicinity of the gas export pipeline corridor (>30 m deep) are typically freely moving through these areas within the water column rather than requiring benthic habitat for internesting activities • While the shallow water area to the east of the Oceanic Shoals marine park overlaps the internesting habitat critical to the survival of flatback turtles, it does not overlap internesting habitat critical to the survival of olive ridley turtles. The shallow water area of the pipeline corridor overlaps approximately 0.15% of the internesting habitat critical to the survival of flatback turtles. Additionally, potential internesting habitat is widespread in the surrounding area. • As the physical presence of the gas export pipeline within internesting habitat critical to the survival of marine turtles has been minimised, i.e. approximately 0.0001% and 0.0015% of the internesting habitat critical to the survival of flatback and olive ridely turtles respectively, the physical presence of the gas export pipeline during operations is considered highly unlikely to impact the species use of the area. The area immediately adjacent to the pipeline (within several hundreds of metres) will experience short term (in the order of days to several weeks) temporary but reversible increases in localised turbidity resulting in a limited indirect seabed disturbance footprint but negligable reduction in quality of available foraging or internesting habitats. • Internesting female turtles will be able to continue to use the habitats within the area identified as habitat critical to the survival of flatback and olive ridley turtles (other than the immediate direct seabed disturbance footprint of the project). It is concluded that the implementation of management controls will allow the activities to be managed to ensure marine turtles are not displaced from identified habitat critical to the survival of the species.

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
		Manage anthropogenic activities in biologically important areas to ensure that biologically important behaviour can continue.	• No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. • Trenching/dredging activities, if required, would only occur outside of the peak internesting periods for both flatback and olive ridley turtles and are unlikely to impact marine turtles resting in shallow waters in the days prior to re-nesting, therefore no impacts to biologically important nesting behaviours are expected. • No impacts at a population/genetic stock level from habitat modification to the benthic environment are expected to occur. • Pipelay/dredging vessels are mobile and will not be at any one location for extended periods of time. Any exposure of internesting females to pipelay installation activities will be temporary. • Given the majority of internesting turtles resting in the days prior to re-nesting are in waters <30 m, by restricting the majority of the pipeline corridor to waters deeper than 30 m, impacts from the pipeline are not expected. Within the pipeline corridor, the only area of waters < 30 m deep is restricted to the 30 km long shallow water area east of the Oceanic Shoals marine park and a pipeline would only be routed through here in the event permission was not granted to lay the pipeline inside the marine park. • Flatback and olive ridley turtles within or in the vicinity of the gas export pipeline corridor (> 30 m deep) are likely to be transiting the area (in the water column), rather than displaying biologically important internesting behaviours (i.e. resting on the seabed from the pipeline footprint prior to re-nesting). • While the shallow water area to the east of the Oceanic Shoals marine park overlaps the internesting habitat critical to the survival of flatback turtles, it does not overlap internesting habitat critical to the survival of olive ridley turtles. The shallow water area of the pipeline corridor overlaps approximately 0.15% of the internesting habitat critical to the survival for flatback turtles. Additionally, potential internesting habitat is widespread in the surrounding area. • Loss of internesting habitat due to the placement of the gas export pipeline will be limited to 0.0001% and 0.0015% of the internesting habitat critical to the survival of flatback and olive ridley turtles respectively. • No impacts at a population/genetic stock level from alterations in biologically important behaviours or changes in the internesting habitat are expected. It is concluded that the implementation of management controls will allow the activities to be managed to ensure that biologically important behaviour can continue.

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)

AMPs	IUCN Principles	IUCN category VI (Multiple Use Zone):
		• The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles.
		• The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term.
		• Management practices should be applied to ensure ecologically sustainable use of the reserve or zone.
		• Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles.
			• The biological diversity and other natural values, and ecologically sustainable use of the Oceanic Shoals marine park will not be affected by installation of the linear gas export pipeline due to:
			  • the corridor overlapping a small portion (708 km^2; approximately 1%) of the Oceanic Shoals marine park. The area of seabed directly disturbed by the gas export pipeline within the Oceanic Shoals marine park will be significantly smaller than the area covered by the corridor (approximately 0.0002% of the marine park)
			  • the fact that benthic habitats within the portion of the marine park overlapped by the pipeline corridor are representative of those within the broader marine park boundary and region (Heyward et al. 2017) (i.e. they are not unique), both characterised predominantly by large areas that support filter feeders, burrowers/crinoids and small areas of corals and macroalgae.
			• To further define the benthic habitats within the marine park and pipeline corridor and allow a robust assessment that the habitats within the portion of the marine park overlapped by the pipeline corridor are represented elsewhere in the marine park outside the pipeline corridor, a collaborative field survey with AIMS was commissioned with the field work completed 8 October 2017. The final report including all analysis and interpretation is due mid Q3 2018. The data will be used to further validate the outputs of the AIMS benthic habitat model and will support the pipeline route selection, as will further pipeline route engineering studies.
			• Installation of the gas export pipeline is a central element of the Barossa project that is expected to contribute to local, regional and national development, and seabed disturbance from these activities is not anticipated to impact on the biological diversity and other natural values of the Oceanic Shoals marine park.

Table 6-15: Summary of impact assessment, key management controls, acceptability and EPOs for seabed disturbance

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome

Seabed disturbance	Physical environment – seabed features.
	
	Marine reptiles.
	
	Shoals and banks.
	
	AMPs – Oceanic Shoals.
	
	KEF – shelf break and slope of the Arafura Shelf, and the carbonate bank and terrace system of the Van Diemen Rise.
		Direct loss or indirect disturbance of benthic habitat.
		
		Physical damage and/ or disturbance to unique seafloor KEFs.
		
		Physical damage and/ or disturbance to benthic habitat within the Oceanic Shoals marine park and to shoals/ banks.
			The project will be undertaken in accordance with the ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as:
			• design planning throughout concept select phase to avoid placement of facilities/ infrastructure within the Barossa offshore development area in areas of regional environmental importance (e.g. shoals, banks, coral reefs, islands, and known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles
			• use of export pipeline selection route surveys to inform route optimisation and reduce environmental impact.
			
			The location of subsea infrastructure within the Barossa offshore development area will be informed by pre-installation surveys/studies that identify and avoid areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles).
			
			Pre-lay surveys of the gas export pipeline installation route will be used to identify areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of the Van Diemen Rise KEFs, seabed related conservation values associated with the Oceanic Shoals marine park or nearby shoals and banks (including Goodrich Bank, Marie Shoal and Shepparton Shoal). The outcomes of the pre-lay surveys will be used to inform route optimisation and reduce environmental impacts.
			
			The MODU/FPSO facility mooring design analysis will include environmental sensitivity and seabed topography analysis to inform selection of mooring locations to avoid areas of seabed that are associated with the seafloor features/ values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles).
			
			Positioning of the MODU will be undertaken in accordance with the mooring design and analysis and the drilling contractors' rig move procedure, which includes procedures for the deployment and retrieval of anchors using support vessels to minimise seabed impacts.
			
			Shallow Hazards Study report will be completed prior to drilling of the development wells and include a review of seabed features to inform well location.
				The residual risk associated with impacts to the Barossa offshore development area is considered low as:
				• Direct disturbance -
				  • the seabed footprint is relatively small at a regional scale with any potential disturbance expected to be very localised.
				  • the Barossa offshore development area does not contain seabed or benthic habitats that are not represented elsewhere.
				• Indirect disturbance -
				  • the placement of infrastructure on the seabed will result in a single brief disturbance resulting in a transient turbid plume.
				• The key management measures are considered effective in addressing potential impacts associated with seabed disturbance from the project. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks.
				• The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.
				• The project aligns with relevant legislative requirements, standards, industry guidelines, ConocoPhillips requirements and the Recovery Plan for Marine Turtles in Australia (**Table 6-14**).
					No permanent disturbance to benthic habitats beyond the physical footprint of offshore facilities/ infrastructure within the Barossa offshore development area and gas export pipeline, as relevant to both direct and indirect sources of disturbance to seabed and associated benthic habitats.
					
					The FPSO facility and in-field subsea infrastructure will be located in the Barossa offshore development area and will not impact the nearest shoals/ banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (which are > 27 km away) and areas of seabed that are associated with the shelf break and slope of the Arafura Shelf KEF.
					
					No anchoring or mooring of the FPSO facility and MODU/vessels on shoals/banks, except in emergency conditions.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome

			A Vessel Anchoring Plan will be prepared which will take into consideration anchoring locations and will confirm no anchoring on shoals/banks.
			
			Heavy lifting operations between vessels and the MODU/drill ship or FPSO facility will be undertaken using competent personnel appropriate and certified lifting equipment and accessories to minimise the risk of dropped objects.
			
			No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods.
			
			Installation schedule of the gas export pipeline will take into consideration seasonal presence/ activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels:
			1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs
			2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP
			3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence
			4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP.
				The residual risk associated with impacts to the gas export pipeline corridor is considered medium as:
				• Direct disturbance -
				  • the seabed footprint is relatively small at a regional scale with any potential disturbance expected to be very localised, including within the Oceanic Shoals marine park.
				  • the gas export pipeline route will be designed through the subsequent route optimisation process to minimise, where practicable, impacts to areas of seabed that are associated with the seafloor features/values of the KEFs and shoals/banks.
				• Indirect disturbance –
				  • should more extensive intervention works (i.e. trenching/dredging) be required during pipelay installation, there is potential for some of the shoals/banks, a portion of the internesting habitat critical to the survival of flatback and olive ridley turtles, the internesting BIA for olive ridley turtles, and a small portion of the known significant seagrass sites for dugongs in the vicinity of the pipeline route to be affected by a sediment plume; albeit short- term (in the order of days to several weeks).
					Minimise disturbance beyond the physical footprint by preventing the loss of significant equipment/ cargo overboard from the MODU/ drill ship, FPSO facility or vessels.
					
					The gas export pipeline route will be designed to minimise, where practicable, impacts to areas of seabed that are associated with the seafloor features/values of KEFs and shoals/ banks.
					
					To minimise impact to representative species, assemblages and associated values of the Oceanic Shoals marine park, further studies will be used to inform final pipeline routing so the pipeline will not be installed on those representative species, assemblages and associated values if they have not been found in the marine park outside the pipeline corridor.
					
					No significant impacts to turtle or dugong populations from impacts (direct or indirect) associated with installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			Dredging/trenching activities for the gas export pipeline installation (if required) will occur outside the peak flatback (June to September) and olive ridley (April to August) turtle internesting period when within the internesting habitat critical to the survival of these species. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/ banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions). Further surveys within the pipeline corridor will be used to supplement existing knowledge from habitat assessments to date, to support an evaluation of the representativeness of species and species assemblages found within the portion of the gas export pipeline corridor that intersects the Oceanic Shoals marine park, with other areas of the marine park. If trenching/dredging activities for the gas export pipeline installation are required, i.e. if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, they will occur outside the peak flatback (June to September) and olive ridley (April to August) turtle internesting period. The following process will be used to identify how the pipeline in the section to be trenched/dredged will be installed to reduce impacts and risks to ALARP and acceptable levels: 1. undertake numerical modelling to predict the extent, intensity and persistence of sediment plumes arising from trenching/dredging activity 2. use the outputs of the numerical modelling to identify key environmental values/sensitivities at risk from trenching/dredging activities with consideration of background/baseline conditions and any seasonal presence 3. update of latest knowledge of how aspects arising from trenching/dredging activities can impact the marine environment, including marine turtles and benthic communities 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above with the understanding of the environment (e.g. benthic habitat maps) to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP, i.e. confirm impacts from trenching/dredging will be temporary and localised. Note: if required, additional controls and/ or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP.	• impacts from indirect disturbance to seabed and benthic habitats are predicted to be temporary in nature and recoverable within months to years depending on the nature of the benthic habitats present within the proximity of the final alignment. Given the broad area in which internesting behaviour for flatback and olive ridley turtles occurs (i.e. resting in waters less than 30 m deep prior to re-nesting) no impacts to biologically important behaviours are expected as a result of indirect impacts from seabed disturbance. Flatback and olive ridley turtles may be present in offshore waters with water depths of up 55 m during the internesting period, however they are typically freely moving through these areas within the water column rather than requiring benthic habitat for internesting activities.	

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			5. develop a dredge management plan that: • details how trenching/dredging will be undertaken (which will be informed by the information derived from items 1-4 above) • identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels • includes an adaptive management strategy for how trenching/ dredging activity will be managed, including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised If use of an anchored pipelay vessel is required, i.e. it may only be required if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, the following process will be used to identify how anchored pipelay installation will be undertaken to reduce impacts and risks to ALARP and acceptable levels: 1. use the information and data derived from the pre-lay survey of the gas export pipeline installation route to update understanding of the existing environment along the gas export pipeline route 2. identify any anchor restrictions zones, i.e. areas where anchors cannot be placed, e.g. shoals, banks or coral outcrops 3. define how installation of the pipeline would be undertaken including start-up anchor pattern, operational anchor pattern and lay down (ending) anchor pattern, and predict the number of anchor drops required 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from 1, 2 and 3, with consideration of any seasonal presence, to evaluate the environmental impacts and risks and to verify the impact assessment conclusions are consistent with those presented in this OPP (Note: if required, additional controls and/or mitigation measures will be identified to be implemented to demonstrate consistency with the impact assessment presented in this OPP) 5. develop a pipeline lay anchoring management plan that: • identifies how pipelay installation would be undertaken using an anchored pipelay vessel • identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels • includes an adaptive management strategy for how anchoring activity will be managed including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised.	• the pipeline corridor has been refined based on geophysical, bathymetric and environmental survey data, to minimise the amount of seabed intervention and stabilisation required. The requirement for, and location of, seabed intervention techniques for the final gas export pipeline route is yet to be defined in detail and the potential environmental impacts and risks associated with the activity will be assessed in further detail in the activity-specific EPs. • The project aligns with the relevant legislative requirements, standards, industry guidelines, ConocoPhillips requirements and the applicable management/ recovery plans and conservation advices (e.g. Recovery Plan for Marine Turtles in Australia and the Australian IUCN Reserve Management Principles listed in **Section 3.5** relevant to key factors for this aspect).	

6.4.4 Invasive marine species (biosecurity)

The project has the potential to translocate and/or introduce IMS to the marine environment, particularly through the discharge of vessel ballast water or marine biofouling on submersible infrastructure/equipment and vessels. The risk assessment for potential impacts to the marine environment due to the unplanned introduction of IMS is summarised in **Table 6-16**.

Table 6-16: Invasive marine species (biosecurity) risk assessment

Risk	Unplanned introduction of IMS from vessel ballast water discharge and biofouling on submersible infrastructure/equipment and vessels.		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor		
Key project stage	All – vessels will be used throughout the life of the project. It is expected that the potential risk may be higher during installation activities, with movement of international vessels.		
Key factor(s) (see Table 6-7)	Shoals and banks	KEFs	
Other relevant factor(s) (see Table 6-7)	Tiwi Islands	Sharks and rays	
	Marine mammals	AMPs	
	Marine reptiles	Commercial fishing	
	Fish		
Potential impact(s)	• Displacement of native marine species. • Reduction in species biodiversity and decline in ecosystem integrity. particularly of shoals/banks and islands. • Socio-economic impacts on commercial fishing.		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	4 Significant (Bio)	1 Improbable	4 Low
Residual risk	4 Significant (Bio)	1 Improbable	4 Low
Confidence	High		

Impact assessment and risk evaluation

Vessels (including MODUs/drill ships), facilities and equipment associated with the project that are sourced from foreign waters have the potential to introduce IMS to the Barossa offshore development area. IMS species are of particular concern due to the potential to influence marine ecosystems such as coral reefs and commercial fisheries and, therefore, lead to indirect impacts to marine fauna. Potential impacts caused by IMS can include effects on benthos via competition for space and food, change in species composition resulting in altered community structures, increased predation pressure to native species, introduction of pathogens, a reduction of biodiversity and biofouling of fishing equipment.

The most common transfer mechanisms for IMS that will require management throughout the life of the project include:

- discharge of vessel ballast water taken up from high risk international or domestic offshore waters
- marine biofouling:
  - on equipment that is regularly submerged in water, such as drilling equipment
  - on hulls of MODUs/drill ships, vessels or the FPSO facility and other external niches, such as thruster tunnels
  - of internal niches of MODUs/drill ships, vessels or the FPSO facility, such as anchor chain lockers, sea chests, strainers and seawater pipework, where relevant.

The risk of introducing IMS is inherently limited by the location of the Barossa offshore development area in deep waters (130 m–350 m) that are not directly adjacent to any shoals/banks. IMS are generally unable to successfully establish in deep water ecosystems (Geiling 2014), most likely due to a lack of light or suitable habitat to sustain the growth and survival of IMS. Therefore, most IMS are found in tidal and subtidal zones with only a few species known to extend into deeper waters of the continental shelf (Bax et al. 2003). In addition, the risk of introducing IMS is considered to be low due to the remote location of the Barossa offshore development area (i.e. approximately 100 km offshore from the Tiwi Islands and 89 km from the nearest coastal waters) and adequate physical separation from offshore shoals/banks (> 27 km) by deep waters.

The northern end of the gas export pipeline corridor is predominantly located in the mid-shelf region where water depths range between approximately 50 m and 120 m. However, the southern end and shallow water area are in shallower waters (< 50 m, with a minimum depth of approximately 5 m in the shallow water area). The shoals/banks of Goodrich Bank, Marie Shoal and Shepparton Shoal are located in the vicinity of the corridor. Therefore, there may be an increased risk of IMS colonising areas along the southern end and within the shallow water area of gas export pipeline corridor in the shallower water depths, where there is suitable light and habitat available (particularly in the vicinity of the shoals/banks). However, the risk of this occurring is considered low given the key management controls that will be implemented throughout the life of the project including a project Quarantine Management Plan, and compliance with contemporary ballast water and biofouling requirements.

The KEF of the shelf break and slope of the Arafura Shelf are located in areas where seabed depths are > 100 m and, therefore, unlikely to be affected by IMS. The KEF of the carbonate bank and terrace system of the Van Diemen Rise and the majority of the open waters associated with the Oceanic Shoals marine park occur in areas where seabed depths range between 50 m and 120 m. However, as outlined above, the likelihood of IMS being introduced as a result of the project are considered to be manageable following implementation of effective key management controls.

Given the suite of management controls that will be implemented throughout the project, the risk of introducing IMS as a result of project activities is considered low and therefore socio-economic impacts on commercial fishing and other marine users in the vicinity of the Tiwi Islands are not expected.

Impact and risk summary

A summary of the potential impacts, proposed key management controls, acceptability and EPOs for IMS are presented in **Table 6-17**. In conclusion, the residual risk of impact to species biodiversity and ecosystem integrity from introduction of IMS is considered low given the open ocean deep water environment and distant proximity to sensitive shoals/banks to the Barossa offshore development area. While vessels related to the gas export pipeline may traverse areas adjacent to values/sensitivities potentially vulnerable to IMS (e.g. Goodrich Bank, Marie Shoal and Shepparton Shoal) it is considered that the controls outlined above can demonstrably manage the risk of potential impacts in these discrete areas.

There are no relevant requirements within any EPBC management plans/recovery plans or conservation advices that are of direct relevance to IMS.

Table 6-17: Summary of impact assessment, key management controls, acceptability and EPOs for invasive marine species (biosecurity)

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome

IMS (biosecurity)	Shoals and banks.
	KEFs – shelf break and slope of the Arafura Shelf, and the carbonate bank and terrace system of the Van Diemen Rise.
		Displacement of native marine species.
		Reduction in species biodiversity and decline in ecosystem integrity, particularly of shoals/banks.
			A Quarantine Management Plan will be developed and implemented, which will include as a minimum:
			• compliance with all relevant Australian legislation and current regulatory guidance
			• outline of when an IMS risk assessment is required and the associated inspection, cleaning and certification requirements
			• implementation of management measures commensurate with the level of risk (based on the outcomes of the IMS risk assessment), such as inspections and movement restrictions
			• anti-fouling prevention measures including details on maintenance and inspection of anti- fouling coatings.
			Ballast water exchange operations will comply with the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 – MARPOL 73/78 (as appropriate to vessel class), Australian Ballast Water Management Requirements (DoAWR 2017) and *Biosecurity Act 2015*, including:
			• all ballast water exchanges conducted > 12 nm from land and in > 200 m water depth
			• vessel Ballast Water Management Plan stipulating that ballast water exchange records will be maintained
			• completion of DoAWR Ballast Water Management Summary sheet for any ballast water discharge in Australian waters.
			The International Convention on the Control of Harmful Anti-fouling Systems on Ships will be complied with, including vessels (of appropriate class) having a valid IAFS Certificate.
			The FPSO facility hull will be subject to an IMS inspection prior to entry into Australian waters.
				The potential impacts and risks associated with the introduction of IMS due to project activities is considered broadly acceptable given:
				• The residual risk is considered low:
				  ◦ given the remote offshore deep water environment and proximity to sensitive shoals and banks to the Barossa offshore development area
				  ◦ the controls outlined are sufficient to manage the risk of impact to values/ sensitivities sensitive to IMS located in discrete areas adjacent to the gas export pipeline corridor (e.g. Goodrich Bank, Marie Shoal and Shepparton Shoal).
				• The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.
				• The project meets the requirements of the environmental legislation, international agreements and conventions and ConocoPhillips requirements (e.g. specifically the *Biosecurity Act* 2015 and the NMR Bioregional Plan).
					Prevent the displacement of native marine species as a result of the introduction and establishment of IMS via project-related activities, facilities and vessels.

6.4.5 Underwater noise emissions

The project will generate underwater noise emissions, associated primarily with the installation phase and operation of the FPSO facility and vessels. The risk assessment for potential impacts associated with underwater noise emissions is summarised in **Table 6-18**.

Table 6-18: Underwater noise emissions risk assessment

Risk	Generation of underwater noise emissions interacting with marine fauna		
Geographic project reference	Barossa offshore development area Gas export pipeline corridor (predominantly during installation)		
Key project stage	Development drilling Installation Operations Decommissioning		
Key factor(s) (see Table 6-7)	Marine mammals	Fish	
	Marine reptiles	Sharks and rays	
Other relevant factor(s) (see Table 6-7)	Plankton	Commercial fishing	
Potential impact(s)	• Behavioural disturbance or physiological damage, such as hearing loss, to sensitive marine fauna. • Masking or interference with marine fauna communications or echolocation. • Auditory impacts on commercial fishing/socio-economic users (i.e. divers).		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	2 Minor (Bio)	2 Remote	4 Low
Residual risk	2 Minor (Bio)	2 Remote	4 Low
Confidence	High		

Impact assessment and risk evaluation

Underwater noise emissions have the potential to affect marine fauna that may transit the project area. Marine fauna use sound in a range of functions including social interaction, foraging and orientation. Marine fauna respond variably when exposed to underwater noise from anthropogenic sources, with effects dependent on a number of factors, including distance from the sound source, the animal's hearing sensitivity, type and duration of sound exposure and the animal's activity at time of exposure (JASCO 2016). Broadly, the effects of sounds on marine fauna can be categorised (JASCO 2016) as:

- acoustic masking – anthropogenic sounds may interfere, or mask, biological signals, therefore reducing the communication and perceptual space of an individual
- behavioural response – behavioural changes vary significantly and may include temporary avoidance, increased vigilance, reduction in foraging and reduced vocalisations. For continuous sounds, a review by Southall et al. (2007) concluded that there were no or limited responses by low-frequency cetaceans to continuous received levels up to 120 dB re 1 µPa. However, an increasing probability of avoidance and other behavioural responses for marine mammals began at 120 to 160 dB re 1 µPa (Southall et al. 2007).

- auditory threshold shift (temporary and permanent hearing loss) – marine fauna exposed to intense sound may experience a loss of hearing sensitivity. Hearing loss may be in the form of a temporary threshold shift (TTS) from which an animal recovers within minutes or hours, or a permanent threshold shift (PTS) from which the animal does not recover.
- non-auditory physiological effects – include increased stress or physiological injury as a result of behavioural response.

The recovery plans and conservation advices for whales (blue, humpback, sei and fin whales) and marine turtles (flatback, olive ridley, green, loggerhead, hawksbill and leatherback turtles) identify anthropogenic noise and acoustic disturbance/interference as a key threat to these EPBC listed species (**Table 3-2**).

Sources of underwater noise emissions throughout various stages of the project include vessel movements, development drilling, VSP (short term), pile driving for installing the FPSO facility moorings (short term activity, if required), installation of the gas export pipeline (short term), normal FPSO operations/offtake, helicopter movements and decommissioning activities. While there may be short-term peaks in underwater noise emissions during the early stages of the project (e.g. installation), ongoing low level underwater noise emissions will be generated during operations. The indicative noise levels associated with some of the key underwater noise emission sources for the project are shown in **Table 6-19** and discussed further below.

Table 6-19: Indicative noise emissions for key project activities

Vessel/facility	Indicative source level (at 1 m)
MODU[1]	157–192 dB re 1µPa @ 1 m (SPL) < 120 dB re 1µPa at 2 km (during active drilling and with the presence of support vessels) (98% of the time)
VSP (well evaluation)[2]	146–190 at 1 m (SEL) 180 dB re 1 uPa2.s at 100 m (SEL)
Pipelay vessel[3]	Non-dynamically positioned vessel: 180 dB re 1µPa @ 1 m (SPL) Dynamically positioned vessel (deep water): 192 dB re 1µPa @ 1 m
Seabed trenching[4]	178 dB re 1µPa @ 1 m (SPL)
Helicopters[5]	101 to 109 at 3 m water depth for altitudes of 610 m to 152 m respectively
FPSO[6]	174 dB re 1µPa @ 1 m
FPSO (using dynamic positioning)[6]	184 dB re 1µPa @ 1 m
Fuel tanker[6]	182 dB re 1µPa @ 1 m
Support vessel[6]	184 dB re 1µPa @ 1 m
Tugs[7]	165–192 dB re 1µPa @ 1 m
Barges[7]	167–179 dB re 1µPa @ 1 m

Source: [1] Woodside 2014, Australian Petroleum Production and Exploration Association (APPEA) 2005; [2] Chevron 2011b, Curtin University of Technology 2013; [3] JASCO 2013; [4] Nedwell et al. 2003; [5] Kent et al. 2016; [6] JASCO 2016; [7] Woodside 2014

Installation vessel movements and development drilling

There may be a period of increased noise emissions during installation activities in the Barossa offshore development area as a result of a higher number of vessels operating at any one time (**Table 4-5**). These activities will extend for a relatively short period in the context of the project life. As shown in **Table 6-19**, the indicative underwater noise levels emitted by vessels (including MODUs/drill ships) can range between 157 to 192 dB re 1 µPa at 1 m. A study undertaken by McCauley and Duncan (2003) recorded underwater noise at 5 km from a drilling rig and found broadband levels of noise during drilling were normally below 110 dB re 1µPa, with support vessel noise exceeding 120 dB re 1 µPa at 5 km for only 0.7% of the time. Another study of a drilling campaign (drilling and supply vessel movements) found that noise levels at 2 km from the drilling rig exceeded 120 dB re 1µPa for only 2% of the time and estimated that significant effects of underwater noise may be confined to within 3 km of the rig (APPEA 2005). Should a dynamically positioned drill ship be used for the project, analogues from a study in the Arctic characterised noise levels of 184–190 dB re 1 µPa at distances of 0.5 km–1 km from the source (Kyhn et al. 2014). Underwater source levels from another dynamically positioned drill ship operating in the Artic were estimated of 193–182 dB re 1 µPa (Austin 2014).

Modelling of medium-frequency noise generated by support vessels used in the Ichthys project was reported as reaching the 120 dB re 1 µPa threshold level at a distance of approximately 3.5 km (occasionally extended up to 7 km) from the vessel in waters 60 m in depth (INPEX 2010). Underwater noise levels of 130–140 dB re 1 µPa from the support vessels were recorded within 1 km (SVT 2009, cited in INPEX 2010). The modelling is considered to provide a representative estimate of potential underwater noise levels from support vessels in the Barossa offshore development area. The underwater noise modelling undertaken for the operation of the FPSO facility, as presented in **Section 6.4.5.4**, is also considered indicative of the predicted noise levels generated by vessels and the potential impacts to marine fauna in the area.

Considering the location of the Barossa offshore development area in open offshore waters that are not within significant feeding, breeding or aggregation areas for marine fauna or directly adjacent to shoal/bank habitat areas, and the sound exposure thresholds of marine fauna to continuous sounds (refer to **Section 6.4.5.3**), the potential for marine fauna individuals to be affected by underwater noise emissions during installation activities is considered low. Any potential impacts are likely to restricted to a small number of individuals that may be traversing through the area.

Most pelagic fish species which may transit through the area are expected to demonstrate avoidance behaviour if noise levels approach those that could cause pathological effects. However, the presence of many oceanic fish near MODUs and support vessels suggests that these species are not adversely affected by the noise associated with these activities and that these structures may actually serve as fish attraction devices (Røstad et al. 2006).

Underwater noise emissions along the gas export pipeline will be primarily associated with vessels (mainly during installation, with periodic vessel activity during periodic maintenance/integrity inspections), with some temporary peaks in noise emissions expected, for example, during seabed intervention activities. Further discussion of underwater noise emissions generated during installation of the gas export pipeline are provided below ('Gas export pipeline installation').

Vertical seismic profiling

VSP activities (utilising a relatively small seismic sound source of approximately 450 cubic inch; **Section 4.3.2.7**) may be undertaken on individual development wells and will be short in duration (approximately 8–24 hours per well). Modelling of the noise generated by VSP operations has been for other locations and it was shown that the broadband sound source level expected to be generated is approximately 190 dB re 1 µPa at 1 m (SPL)(Chevron 2011b). A study undertaken by Curtin University of Technology (2013) estimated that for a small seismic array of 440 cubic inch, the expected sound exposure level (SEL) per shot received would be 180 dB re µPa^2•s at 100 m and dissipate to 160 dB re 1 µPa^2•s at 500 m, and 144 dB re 1 µPa^2•s at 2 km.

The single shot (i.e. sound pulse from a single hammer strike) and impulsive sound source (e.g. VSP and pile driving) behavioural thresholds for cetaceans are 160 dB dB re 1 µPa^2•s (SEL) (DEWHA 2008d) and 160 dB dB re 1 µPa (SPL) (National Marine Fisheries Service (NMFS) 2017), respectively. Physical damage (injury) to the auditory system of cetaceans is likely to occur above 179 dB re 1 µPa^2•s (SEL_{24}) if the individual is constantly exposed over a 24-hour period (Wood et al. 2012). Sound exposure guidelines for marine turtles and fish have defined thresholds for impulsive noise sources and are presented in **Table 6-20** (Popper et al. 2014). In addition, the behavioural threshold for marine turtles for impulse noise sources is 166 dB re 1 µPa (National Science Foundation 2011).

Given the expected sound levels (based on the studies above) and thresholds of marine fauna, there is the potential for behavioural change responses to marine mammals, marine reptiles and fish in close proximity to the VSP source (within hundreds of metres). The Barossa offshore development area and immediate surrounds do not contain any significant feeding, breeding or aggregation areas for marine mammals and reptiles. Therefore, there is likely to be a limited abundance of individuals present in the area at any time with individuals likely to be traversing through the area.

No impacts to the catchability of commercial fish species is anticipated as behavioural responses are anticipated to be mostly limited to within close proximity of the source (i.e. within hundreds of metres). The Barossa offshore development area represents a small portion of habitat available to commercial fish populations in the Timor Sea. Consequently, behavioural responses as a result of acoustic emissions from VSP are unlikely to affect any species at the population level, and impacts to spawning populations are not expected. Although the Barossa offshore development area is within the Timor Reef Fishery, it represents a small portion of the total area available to both the fishery and the habitat for key target species.

Table 6-20: Impulsive noise threshold criteria applied for turtles and fish

Marine fauna group	Mortality and potential mortal injury		Recoverable injury		TTS	Masking	Behaviour
	SEL (dB re 1 $\mu Pa^2 \cdot s$)	Peak (PK) Pressure (dB re 1 μPa)	SEL (dB re 1 $\mu Pa^2 \cdot s$)	PK Pressure (dB re 1 μPa)	SEL (dB re 1 $\mu Pa^2 \cdot s$)		
Turtles	210	207	N) High (I) Low (F) Low		(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	N) High (I) Moderate (F) Low
Fish: no swim bladder (Fish I; particle motion detection)[1]	219	213	216	213	186	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (Fish II; particle motion detection)	210	207	203	207	186	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is involved in hearing (Fish III; primarily pressure detection)	207	207	203	207	186	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and larvae (plankton)	210	207	(N) Moderate (I) Low (F) Low		(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: Relative risk (high, moderate, low) is provided for marine fauna at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F). All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist.

[1] Representative of sharks and whale sharks

Installation of the FPSO facility moorings

As discussed in **Section 4.4.3**, suction piling or anchoring is the preferred method for securing the mooring lines for the FPSO facility or any other supporting infrastructure associated with the project. However, future geotechnical investigations in the Barossa offshore development area may indicate pile driving is necessary to ensure the facilities/infrastructure are adequately secured and able to withstand severe weather conditions (i.e. cyclones).

Discussion of the underwater noise modelling undertaken and the potential impacts from pile driving are provided in **Section 6.4.5.1** and **Section 6.4.5.2** below.

Gas export pipeline installation

Underwater noise will be generated by vessels and seabed intervention activities during the installation of the gas export pipeline. While several support vessels will be present, the pipelay vessel will be the largest source of noise due to it being the largest vessel. The smaller support vessels will result in a negligible increase in overall noise emissions and therefore are not considered separately.

A study by Nedwell and Edward (2004) measured underwater noise from the dynamically positioned *Solitaire* pipelay vessel at distances between 200 m and 10 km while the vessel was laying a pipeline in deep water (depths between 100 m–250 m) west of the Shetland Islands (north-east of Scotland). The highest SPLs were recorded at a distance of approximately 400 m and showed an almost linear spectrum ranging from 120 dB re 1 µPa at 50 Hz to 80 dB re 1 µPa at 10 kHz (Nedwell and Edward 2004).

Several studies have characterised underwater noise emissions during pipeline trenching activities. Noise levels associated with the trenching of cables into the seabed (by water jetting in water depths of 7 m–11 m) at North Hoyle in Wales were 123 dB re 1 µPa at 160 m, which was interpreted as 178 dB re 1 µPa at 1 m (Nedwell et al. 2003). Underwater noise measurements were recorded by Chevron for the Gorgon project during a trenching trial of mechanical trenching equipment. Noise measurements were taken at 20 m, 30 m, and 50 m in both idle and full trenching mode. During the full trenching mode, the maximum noise level recorded was 80 dB re 1 µPa at 1 to 2 kHz (Chevron Australia 2010g, 2010h, cited in Chevron 2014a), which is below the defined thresholds for marine fauna.

Underwater noise from rock dumping and the placement of sand/grout bags is expected to be negligible. A study measuring underwater noise during rock placement by a fall-pipe rock installation vessel in Yell Sound (north of Scotland) concluded there was no evidence that rock placement contributed to underwater noise levels (Nedwell and Edward 2004). Vessel noise was observed to be the dominant source of noise. A review of underwater sound produced by oil and gas activities also stated that noise measurements from rock dumping and pipeline trenching activities were insignificant compared to those generated by construction vessels (Genesis Oil and Gas Consultants 2011).

No significant feeding, breeding or aggregation areas for marine mammals, sea snakes, fish, sharks or rays are known within the gas export pipeline corridor. However, the pipeline corridor traverses internesting habitat critical to the survival of flatback and olive ridley. Therefore, flatback and olive ridley turtles in particular may transit the area in higher numbers (when compared to the Barossa offshore development area), particularly during the peak internesting period (June to September to for flatbacks and April to August for olive ridley turtles) (**Table 5-12**). Thresholds for behavioural response and injury to marine turtles from noise are summarised in **Table 6-21**.

The waters off the north coast of the Tiwi Islands are recognised as a key site for the conservation of dugongs as they support a significant aggregation of individuals (**Figure 5-17**). A portion of the gas export pipeline corridor is in proximity to the known aggregation area and therefore individuals may transit through a small portion of the pipeline corridor. Hearing capabilities of dugongs are poorly understood and there is a lack of scientific data specific to dugongs for determining injury and behavioural disturbance as a result of underwater noise. Dugongs have been observed to exhibit short-term behavioural responses to vessel noise including interruptions to feeding, changes in swimming speed and direction, modification of vocal behavior and brief separation of females from offspring. However, despite these short term behavioural responses there is no evidence to suggest dugongs are permanently displaced from key habitats by noise (Great Barrier Reef Marine Park Authority (GBRMPA) 2016). The Great Barrier Reef Marine Park Guidelines for Dugong Impact Assessment (GBRMPA 2016) states hearing frequency ranges for dugongs are typically from 1 to 18 kHz. Thus, underwater noise pollution at frequencies of 1 to 18 kHz has the potential to interfere with communication between individual dugongs. Frequency ranges summarised above for similar activities are predominantly outside of this range and therefore not expected to materially affect communication between individuals.

While underwater noise generated by installation activities may affect individuals passing through the area, impacts at a population level are considered unlikely given the area affected is localised (within hundreds of metres; refer to **Section 6.4.5.4**) and only represents a very small portion of the habitat available to marine turtles and dugongs within the Timor Sea. The key noise sources associated with installation activities along the gas export pipeline will also be relatively slow moving (approximately 3 km–5 km of the gas export pipeline will be laid per day), thereby allowing individuals to move away from the area, and reasonably short in duration as installation of the entire pipeline will take in the order of 6–12 months. In addition, the installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of flatback turtles internesting within the vicinity of the Tiwi Islands during development of the gas export pipeline installation EP.

No significant impacts to the catchability of fish species targeted by commercial or Indigenous fishers are expected given the short duration and localised nature of any potential impacts (within hundreds of metres), as discussed above. Therefore, the area of the marine environment influenced by underwater noise associated with the installation of the gas export pipeline represents a very small proportion of the area available to be fished.

Given the relatively localised source of noise from vessels and short duration of installation activities at any one location, significant impacts on any marine fauna transiting through the area are highly unlikely.

FPSO facility operations

There will be low level noise associated with operation of the FPSO facility within the Barossa offshore development area. This may include the periodic use of thrusters during offtake activities (once every 80–100 days).

Discussion of the underwater noise modelling undertaken and the potential impacts from FPSO facility operations are provided in **Section 6.4.5.3** and **Section 6.4.5.5** below.

Helicopters

Helicopter transfers will occur during all stages of the project. The level of received noise from helicopters depends on helicopter altitude, aspect and strength of noise emitted, and other variables such as water depth and depth of the receptor (Woodside 2014). The highest received levels will occur at lower altitudes when the helicopter is approaching the FPSO facility for landing. Received levels from the Bell 212 helicopter ranged from 101 to 109 dB re 1 uPa at distances ranging from 152 to 610 m (Kent et al. 2016). In general, helicopter noise is of short duration (i.e. during take-off and landing) and will be limited to the immediate vicinity of the FPSO facility. Some behavioural disturbance may occur for short periods if marine fauna are present near the surface in the vicinity of landing helicopters.

Decommissioning

Considering that the project is in the early design phase, and given the expected life of the project is approximately 25 years, it is premature to define a decommissioning strategy that aims to address environmental impacts in detail in this OPP. Underwater noise arising from decommissioning activities at the end of the field life are expected to be broadly comparable with that generated from installation activities, as discussed above. As described in **Section 4.3.4**, underwater noise is considered a key decommissioning risk and therefore typical impacts from decommissioning activities have been summarised below for this aspect.

Decommissioning activities are unlikely to generate significant sound levels. The key source of underwater noise will be from vessels in the Barossa offshore development area and the removal of infrastructure. It is expected that the types of vessels used during decommissioning activities will be similar to those used for installation (**Table 4-5**). Therefore, the noise profile will likely be broadly comparable with noise generated from installation vessel movements, as evaluated and discussed above.

A detailed EP specific to decommissioning activities will be prepared for review and acceptance towards the end of the field life for the Barossa project. At that time, a detailed evaluation of environmental risk and impacts will be undertaken, with practicable options assessed for ALARP and acceptability. A commitment to meet this forward process is reflected in **Section 7** of this OPP.

6.4.5.1 Overview of underwater noise modelling – pile driving

An underwater noise modelling study was conducted by JASCO (2017) to assess underwater sound propagation levels associated with the pile driving activities in the Barossa offshore development area (**Appendix N**). The study modelled a number of different scenarios with variations in water depth, pile type (length and diameter), hammer size and penetration efficiencies. These scenarios were defined to understand how variations in the activity could influence the underwater noise emission profile and its extent. The scenarios were based on early engineering definition and available information on the geological profile of the area. As further geological analysis is likely to be undertaken as the project design phase progresses, two of the modelled scenarios (Scenario 9 and 10) conservatively assumed a higher penetration efficiency. Higher penetration efficiencies are generally known to generate a larger cumulative noise footprint. The range of scenarios modelled are considered to provide a conservative estimate of the potential impacts and risks to marine fauna from pile driving activities undertaken in the Barossa offshore development area.

The study applied widely recognised scientifically based thresholds defined by DEWHA (2008d), NMFS (2017) and Wood et al. (2012) for single shot and behavioural response and injury (PTS), respectively, for the various functional hearing groups of cetaceans.

The mortality, recoverable injury, TTS, masking and behavioural thresholds (quantitative and qualitative) for impulsive noise sources as defined in the sound exposure guidelines for marine turtles and fish were applied, as presented in **Table 6-20** (Popper et al. 2014). In addition, the behavioural threshold for marine turtles (166 dB re 1 µPa) for impulse noise sources was also assessed (National Science Foundation 2011).

Some of the potential impacts, mostly related to masking and behavioural change, for turtles, sharks (i.e. fish without swim bladders, and which also includes whale sharks), fish eggs and larvae were assessed qualitatively (i.e. by assessing relative risk rather than by a specific threshold). The modelling study applied this approach, as used by Popper et al. (2014), as there are no widely used scientific-based thresholds for these aspects of impulsive noise sources. In summary, the likelihood of the potential impact occurring considers the distance from the noise source in terms of near (within tens of metres), intermediate (within hundreds of metres) and far (thousands of metres). The relative risk of that impact was then rated as being high, moderate or low with respect to source distance and marine fauna type. The qualitative criteria defined by Popper et al. (2014) for impulsive sound is provided in **Table 6-20**.

6.4.5.2 Pile driving underwater noise modelling results and impact assessment

Marine mammals

Modelling predicted underwater noise emissions would reach the cetacean behavioural response threshold for impulsive sound sources of 160 dB re 1µPa within approximately 28.8 km (JASCO 2017; **Table 6-21** and **Figure 6-4**). The PTS threshold for marine mammals, which is based on the unlikely assumption that the individual remains within this noise range for a continuous 24 hours, was approximately 6.1 km, 0.8 km and 18.8 km for low, mid and high-frequency cetaceans respectively (**Figure 6-5**).

As discussed in **Section 4.3.5.3**, the baseline noise study recorded a number of cetaceans present in the Barossa offshore development area with all of the species detected having broad distributions within Australian waters (**Section 5.6.2**). Significant impacts to cetaceans at a population level from underwater noise generated by the short-duration pile driving activities (in the order of approximately four weeks) is considered highly unlikely given the project does not contain any regionally significant feeding, breeding or aggregation areas for marine mammals. While the behaviour of individuals transiting through the area may be affected, these individuals are not expected to be injured as they would likely be exposed for only a relatively short period of time. As outlined above, the animal would only be injured if it remained at a fixed location within that range of the noise footprint, which is considered unlikely (JASCO 2017).

Marine turtles

Underwater noise emissions generated from pile driving activities were predicted to cause behavioural responses or injury within approximately 14.4 km and 0.2 km, respectively (JASCO 2017; **Table 6-21** and **Figure 6-4** and **Figure 6-6**). Considering the open ocean location of the Barossa offshore development area and significant distance to internesting habitat critical to the survival of marine turtles and shoals/banks, only individual turtles may be affected as they transit the area. No impacts at a population level are anticipated.

Fish and sharks

Modelling predicted underwater noise emissions would reach the TTS and recoverable injury thresholds for fish within approximately 14.8 km and < 0.7 km, respectively (**Table 6-21** and **Figure 6-6**). Injury to individuals was expected to occur within approximately < 0.3 km. Given the small area in which injury from pile driving noise emissions could occur and the location of the Barossa offshore development area in open ocean waters that do not contain any BIAs, only individuals are likely to be affected as they move through the area. No impacts at a population level are expected.

No impacts to the catchability of commercial fish species is expected as the Barossa offshore development area is not actively fished (**Table 5-9**). In addition, the area in which behavioural impacts to fish species may occur does not intersect any shoals/banks.

Table 6-21: Maximum distance to pile driving noise thresholds for marine mammals, turtles, fish and sharks

Species	Threshold	Maximum horizontal distance (km)
Marine mammals – low, mid and high-frequency cetaceans	(In response to a single strike) – 160 dB re 1 µPa²•s (SEL)	9.80
	Behavioural (in response to impulsive sound sources) – 160 dB re 1 µPa (SPL)	28.76
Marine mammals – low-frequency cetaceans	Injury (PTS) – 192 dB re 1 µPa²•s (SEL_{24}) (assumes constant exposure over a 24-hour period)	6.07
Marine mammals – mid-frequency cetaceans	Injury (PTS) – 198 dB re 1 µPa²•s (SEL_{24})	0.79
Marine mammals – high-frequency cetaceans	Injury (PTS) – 179 dB re 1 µPa²•s (SEL_{24})	18.75
Turtles	Behavioural – 166 dB re 1 µPa (SPL)	14.41
	Injury (mortality or potential mortal injury) – 210 dB re 1 µPa²•s (SEL_{24}) and 207 dB re 1 µPa (PK)	0.23 and 0.20
Fish: no swim bladder (representative of sharks and whale sharks)	Recoverable injury – 216 dB re 1 µPa²•s (SEL_{24})	0.11
	Injury (mortality or potential mortal injury) – 219 dB re 1 µPa²•s (SEL_{24}) and 213 dB re 1 µPa (PK)	0.08 and 0.10
Fish: swim bladder involved in hearing	Recoverable injury – 203 dB re 1 µPa²•s (SEL_{24})	0.67
	Injury (mortality or potential mortal injury) – 207 dB re 1 µPa²•s (SEL_{24}) and 207 dB re 1 µPa (PK)	0.34 and 0.20
Fish: swim bladder not involved in hearing	Recoverable injury – 203 dB re 1 µPa²•s (SEL_{24})	0.67
	Injury (mortality or potential mortal injury) – 210 dB re 1 µPa²•s (SEL_{24}) and 207 dB re 1 µPa (PK)	0.23 and 0.20
All fish	TTS – 186 dB re 1 µPa²•s (SEL_{24})	14.81

Socio-economic users

As outlined in **Section 5.7.12**, commercial divers are used to collect species for the NT Aquarium Fishery and may be operating year-round at the nearest shoals/banks to the Barossa offshore development area, specifically Evans Shoal (35 km to the west). Given safe diving depth restrictions, diving activities are typically restricted to relatively shallow waters (< 30 m) at these features.

Divers exposed to high levels of underwater noise can suffer from dizziness, hearing damage or other injuries to other sensitive organs, depending on the frequency and intensity of the sound (Ainslie 2008). Underwater auditory threshold curves indicate that the human auditory system is most sensitive to waterborne sound at frequencies between 400 Hz to 1 kHz (with a peak at approximately 800 Hz) and, therefore, these frequencies have the greatest potential to cause damage to divers (Anthony et al. 2009). The predominant energy in pile impact impulses is at frequencies below 500 Hz (Laughlin 2006; Reyff 2008, 2012, cited in Popper et al. 2014). The modelling of pile driving in the Barossa offshore development area aligns with this the peak sound energy was concentrated in the frequency range 40 Hz to 500 Hz (JASCO 2017).

It is noted that there is some variation in the published acceptable underwater noise received levels for divers, as summarised below (as presented in Ainslie 2008):

- North Atlantic Treaty Organisation (NATO) safety guidelines for military divers: 160 dB re 1 µPa (125 Hz–4,000 Hz)
- NATO guidelines for recreational divers: 154 dB re 1 µPa (600 Hz–2,500 Hz)
- Parvin et al. guidelines (based on joint United Kingdom-United States research): thresholds of 176 dB re 1 µPa for temporary dizziness and 180 dB re 1 µPa for perception of body vibration (500 Hz–2,500 Hz).

In addition, potential impacts of underwater noise exposure for divers from low frequency sound (100 Hz–500 Hz) have also been defined. Parvin (2005) states that for low frequency sound a diver is able to perceive body vibration at 130 dB re 1 µPa and experience clearly audible noise at 136-140 dB re 1 µPa (as a slight aversion for the majority of divers). The loudness and vibration levels become increasingly aversive at 148–157 dB re 1 µPa with levels of 170 dB re 1 µPa representing the tolerance limit for divers (Parvin 2005).

Based on the results of the pile driving underwater noise modelling study, underwater noise emissions were predicted to reach a threshold of 150 dB re 1 µPa within approximately 25 km (JASCO 2017). Underwater noise levels > 170 dB re 1 µPa were limited to within approximately < 3 km (JASCO 2017). Therefore, no adverse impacts to divers undertaking fishing activities within the NT Aquarium Fishery are expected by underwater noise emissions from piling activities in the Barossa offshore development area, which is well removed from the nearest shoals/banks.

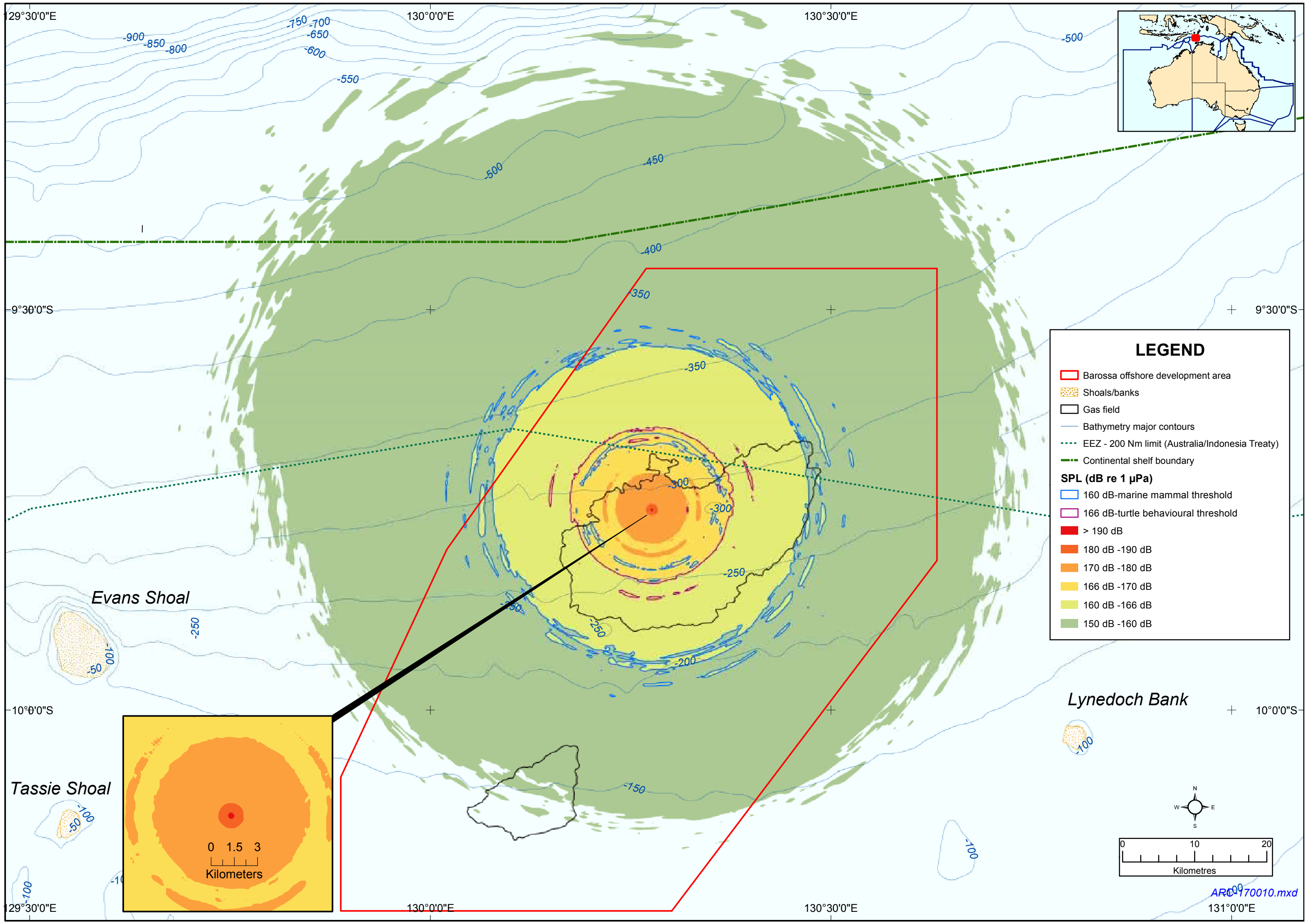


Figure 6-4: Underwater noise levels from pile driving activities – SPL with marine mammal and turtle behaviour threshold

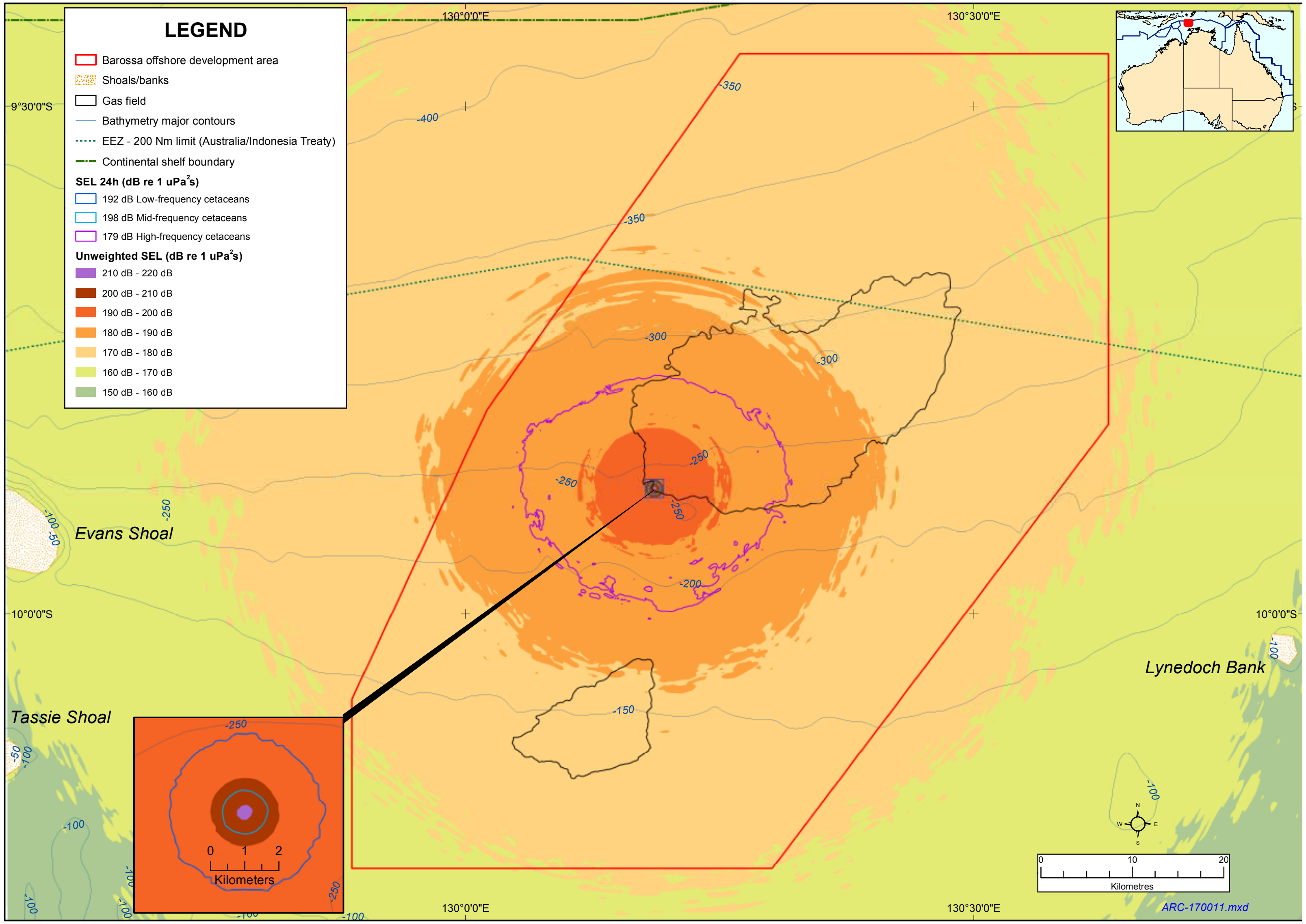


Figure 6-5: Underwater noise levels from pile driving activities – SEL_{24} with marine mammal PTS thresholds

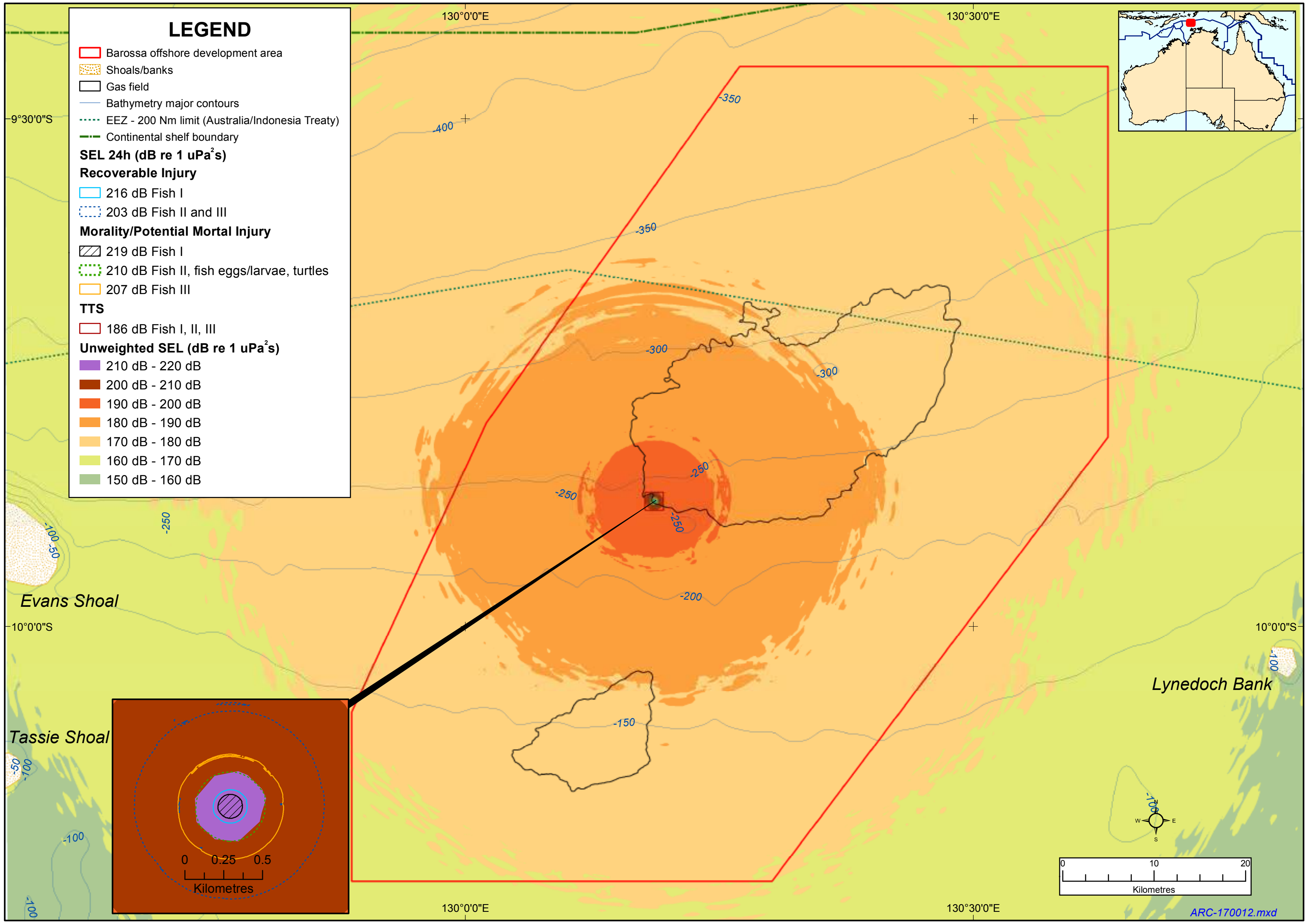


Figure 6-6: Underwater noise levels from pile driving activities – SEL_{24} with fish and turtle thresholds

6.4.5.3 Overview of underwater noise modelling – FPSO facility

An underwater noise modelling study was conducted by JASCO (2016b) to assess underwater sound propagation levels associated with the project (**Appendix O**). The study modelled the FPSO facility operating under two scenarios:

- Scenario 1 – normal operations over a 24-hour period (i.e. without the use of thrusters)
- Scenario 2 – during 24 hours of offtake (i.e. using dynamic positioning systems of the offtake tanker (thrusters)).

As outlined in **Section 4.3.3.1**, offtake is expected to occur approximately every 80–100 days, based on the production rate of the field.

The widely recognised scientifically based thresholds defined by Southall et al. (2007) for behavioural response and the onset of PTS and TTS for the various functional hearing groups of cetaceans were applied to the study. In addition to specific cetacean behavioural response thresholds, an unweighted response threshold of 120 dB re 1µPa was applied as a precautionary threshold for marine mammal behavioural response to continuous noise (NMFS 2017). This precautionary threshold does not take into account the hearing abilities of different species groups (i.e. it is unweighted). It is interesting to note that this threshold is marginally above the upper range of the average ambient sound levels recorded during the Barossa marine studies program (approximately 97–119 dB re 1 µPa) (JASCO 2016a); which suggests that marine fauna in the area are naturally exposed to a reasonably 'noisy' environment. The thresholds for PTS and TTS onset for cetaceans relate to the cumulative SEL (dB re 1 $\mu Pa^2 \cdot s$), which is combined over a 24-hour period or for the duration of the activity (e.g. operation of the FPSO facility and offtake).

Masking and behavioural effects were assessed qualitatively (i.e. by assessing relative risk rather than by a specific threshold) for turtles, sharks (i.e. fish without swim bladders, and which also includes whale sharks), fish eggs and larvae. The modelling study applied this approach, as used by Popper et al. (2014), as there are no widely used scientific-based thresholds for these marine fauna groups for these aspects of continuous noise sources. The qualitative criteria defined by Popper et al. (2014) for continuous sounds is provided in **Table 6-22**.

Table 6-22: Qualitative continuous underwater noise criteria for turtles, sharks, fish eggs and larvae

Marine fauna group	Impairment			Behaviour
	Recoverable injury	TTS	Masking	
Turtles	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Fish: no swim bladder (particle motion detection)[1]	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Low (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder is involved in hearing (primarily pressure detection)	170 dB SPL for 48 hour	158 dB SPL for 12 hour	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Fish eggs and larvae (plankton)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Notes: Relative risk (high, moderate, low) is provided for marine fauna at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F). All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist.

[1] Representative of sharks and whale sharks

The recognised threshold criteria outlined in Popper et al. (2014), as shown in **Table 6-22**, were applied to assess impacts on fish exposed to continuous sound. Due to the absence of clearly defined thresholds for sea snakes, the threshold criteria for fish have been applied as a surrogate as only quantifiable distances for continuous sounds exist for fish (JASCO 2016b). These thresholds are considered to reflect a conservative assessment of the effects of noise on sea snakes.

6.4.5.4 FPSO facility underwater noise modelling results and impact assessment

Marine mammals

Modelling predicted underwater noise emissions would reach the unweighted cetacean behavioural response threshold of 120 dB re 1µPa within approximately 1.4 km and 11.4 km during normal operations and offtake, respectively (**Table 6-23**). Noise emissions during normal operations dropped below 160 dB re 1µPa within approximately < 10 m from the FPSO, while during offtake this distance was approximately < 20 m (JASCO 2016b). **Figure 6-7a,b** shows the SPL as related to behavioural thresholds for marine mammals. The PTS threshold (215 dB re 1 µPa^2•s) for all marine mammals was predicted to be in close proximity to the source, with < 10 m for normal operations and < 20 m during offtake operations (**Figure 6-8a,b**).

A number of cetaceans were recorded in the Barossa offshore development area with all of the species having broad distributions within Australian waters (**Section 5.6.2**). Impacts to cetaceans at a population level from underwater noise generated by the project is considered highly unlikely given the Barossa offshore development area does not contain any regionally significant feeding, breeding or aggregation areas for marine mammals, including those EPBC listed species identified as potentially occurring in the area (**Section 5.6.2**). Any spatial and temporal scale of behavioural response effects would be limited to the localised area surrounding the FPSO facility (JASCO 2016b). Therefore, only individual marine mammals that transit the Barossa offshore development area may be affected, with these individuals being exposed for only a relatively short period of time. Significant impacts at a population level are not expected.

Underwater noise generated by the FPSO facility, and project vessels in general, could result in longer-range acoustic masking effects. The area in which masking may occur is species dependent as it is influenced by their call frequency and hearing range (**Table 6-24**). Odontocetes will likely only experience masking for the low frequency components of their calls, with this effect expected to be limited to the immediate vicinity of the FPSO facility (JASCO 2016b). It is not anticipated to affect odontocetes' (e.g. killer whale, sperm whale and dolphins) ability to echolocate when feeding due to the frequency range of their echolocation clicks (JASCO 2016b). Pygmy blue whales, Bryde's whales and Omura's whales will experience masking when in the vicinity of the FPSO. The area in which masking may occur is expected to be larger for Bryde's whales than pygmy blue whales considering they have lower vocalisation levels (JASCO 2016b). In terms of the Barossa offshore development area, masking effects are more relevant to Bryde's whales and Omura's whales as they appear to exhibit a more regular presence within the region (January to early October and April to September, respectively), whereas the migratory pygmy blue whales will only be affected for a short period of time as they transit the area.

As outlined in **Section 5.6.2**, the primary migratory route for humpback whales is well understood with relatively few individuals known to travel north of Camden Sound (Jenner et al. 2001), which is located more than approximately 820 km south-west of the Barossa offshore development area. Therefore, underwater noise emissions associated with the project will not affect this species.

In general, considering the open water location of the project, known movements of marine fauna in the area and the distance to BIAs, underwater noise generated from the project is considered unlikely to significantly affect these key values and sensitivities, particularly at a population level.

Marine turtles

As indicated by the qualitative criteria defined by Popper et al. (2014), temporary impairment from continuous sounds to marine turtles due to TTS is expected to only occur at close ranges (within tens of metres) (JASCO 2016b). Behavioural impacts or masking effects may occur at close to intermediate ranges (within hundreds of metres). Considering the open ocean location of the Barossa offshore development area and significant distance to internesting habitat critical to the survival of marine turtle species, only individual turtles may be affected as they transit the area. No impacts at a population level are anticipated.

Fish and sea snakes

Modelling predicted underwater noise emissions would reach the TTS and recoverable injury thresholds for fish (and sea snakes, using these thresholds as a surrogate) within approximately < 10 m during both normal operations and offtake (**Table 6-23**). Where qualitative criteria do not exist for some fish species **Table 6-22**, temporary impairment from continuous sounds due to TTS is expected to only occur at close ranges (within tens of metres) (JASCO 2016b). Behavioural impacts may occur at close to intermediate ranges (within hundreds of metres). Considering this, the open ocean location of the Barossa offshore development area and the absence of BIAs, only individuals are likely to be affected as they move through the area. No impacts at a population level are expected.

No impacts to the catchability of commercial fish species is expected considering the very localised area in which behavioural impacts may occur and given the Barossa offshore development area is not actively fished (**Table 5-9**).

Potential impacts to plankton, fish eggs and fish larvae are considered to be extremely low (compared to natural mortality rates, e.g. predation), and any impacts (i.e. mortality and tissue damage) that do occur are likely to be limited to within the immediate proximity (< 5 m) of the FPSO facility (JASCO 2016b). No impacts at a population level are expected given the localised nature of any impacts and the widespread distribution of the species.

Sharks and rays

Cartilaginous fish (such as sharks and rays) lack a swim bladder and are, therefore, considered less sensitive to underwater noise than bony fish. While limited research has been undertaken on the hearing capabilities of sharks, it has been suggested they are most sensitive to low frequency sound (40 Hz to approximately 800 Hz), which is sensed solely through the particle-motion component of an acoustical field (Myrberg 2001). Klimley and Myrberg (1979) established that an individual shark will suddenly turn and withdraw from a sound source of high intensity (more than 20 dB re 1µPa above broadband ambient SPL) when approaching within 10 m of the sound source. A study by Sand (1981, cited in Myrberg 2001) suggested that the lateral line system does not respond to normal acoustical stimuli and is, therefore, unable to detect sound-induced water displacements beyond a few body lengths, even with large sound intensities (Myrberg 2001).

Based on these studies and qualitative criteria defined by Popper et al. (2014), it is possible that sharks and rays may detect elevated underwater noise levels and exhibit avoidance measures when in close proximity to the noise source (e.g. MODUs/drill ships, FPSO facility, project vessels). However, it is expected that any potential impacts would be short term, with affected individuals returning to normal behaviours after avoiding the noise source. Specifically, temporary impairment from continuous sounds to sharks due to TTS is expected to only occur at close ranges (within tens of metres), with behavioural impacts potentially occurring at close to intermediate ranges (within hundreds of metres) (**Table 6-22**; JASCO 2016b). Considering the location of the project (i.e. mostly open offshore waters), the scale of project in a broader regional context and the absence of any BIAs for the species, it is considered highly unlikely that underwater noise emissions from the project will result in significant changes in habitat usage by sharks and rays that may transit the area.

Table 6-23: Maximum distance and area to noise thresholds for cetaceans and fish

Scenario	SPL threshold	Maximum horizontal distance (km)
Marine mammals		
Scenario 1: FPSO facility – normal operations	120 dB re 1µPa	1.4
Scenario 2: FPSO facility – offtake operations		11.4
Fish (swim bladder involved in hearing)^		
Scenario 1: FPSO facility – normal operations	Recoverable injury: 170 dB for 48 hours TTS: 158 dB for 12 hours	< 10 m (both recoverable injury and TTS)

^ In the absence of defined threshold criteria for sea snakes, the SPL thresholds for fish have been conservatively applied.

Table 6-24: Marine fauna hearing frequencies compared with anthropogenic noise sources

Marine fauna	Hearing sensitivity range (Hz)
Cetaceans – low-frequency (e.g. pygmy blue whale, Bryde's whale, humpback whale and Omura's whale)[1]	7–22,000
Cetaceans – mid-frequency (e.g. odontocetes, including the majority of dolphin species)[1]	150–160,000
Cetaceans – high-frequency (e.g. odontocetes specialised for using high frequencies, i.e. genera *Kogia* and *Cephalorhynchus*, porpoises and river dolphins)[1]	200–180,000
Turtles[1]	50–2,000
Fish[1]	50–2,000 (most often 100-500)
Sharks[2]	40–80
Anthropogenic noise source	**Noise frequency (Hz)**
Vessels[3]	10–1,100
Drilling[3]	10–1,100
FLNG[3]	10–1,100
Pile driving[4]	< 500
Seismic airguns[4]	20–50

Source: [1] JASCO 2016b; [2] Myrberg 2001; [3] Woodside 2014; [4] Popper et al. 2014

Socio-economic users

As outlined in **Section 5.7.12**, commercial divers collect species for the NT Aquarium Fishery and may be operating year-round at the nearest shoals/banks to the Barossa offshore development area, specifically Evans Shoal (35 km to the west).

As described in **Section 6.4.5.2**, humans are most sensitive to waterborne sound at frequencies between 400Hz to 1 kHz (with a peak at approximately 800 Hz) and, therefore, these frequencies have the greatest potential to cause damage to divers (Anthony et al. 2009). The sounds of vessels are predominately low frequency (i.e. below 1 kHz) (Popper et al. 2014), with source levels from large vessels generally below 500 Hz (Anthony et al. 2009). For example, source levels from tankers range from 188 to 192 dB re 1 µPa @ 1 m, while drill ships generate broadband source levels of 185 dB re 1 µPa @ 1 m (Anthony et al. 2009). MODUs generate source levels between 159 and 176 dB re 1 µPa @ 1 m while drilling.

Considering the underwater noise thresholds for divers outlined in **Section 6.4.5.2** and based on the resultsof the FPSO facility underwater noise modelling study, underwater noise emissions were predicted to reach a threshold of 130 dB re 1 µPa within approximately 220 m and 2.1 km during normal operations and offtake, respectively (JASCO 2016b). Noise emissions at the level of 160 dB re 1 µPa were expected to be reached within < 20 m (JASCO 2016b). Therefore, no impacts to divers undertaking fishing activities within the NT Aquarium Fishery are expected from underwater noise emissions in the Barossa offshore development area, which is well removed from the nearest shoals/banks.

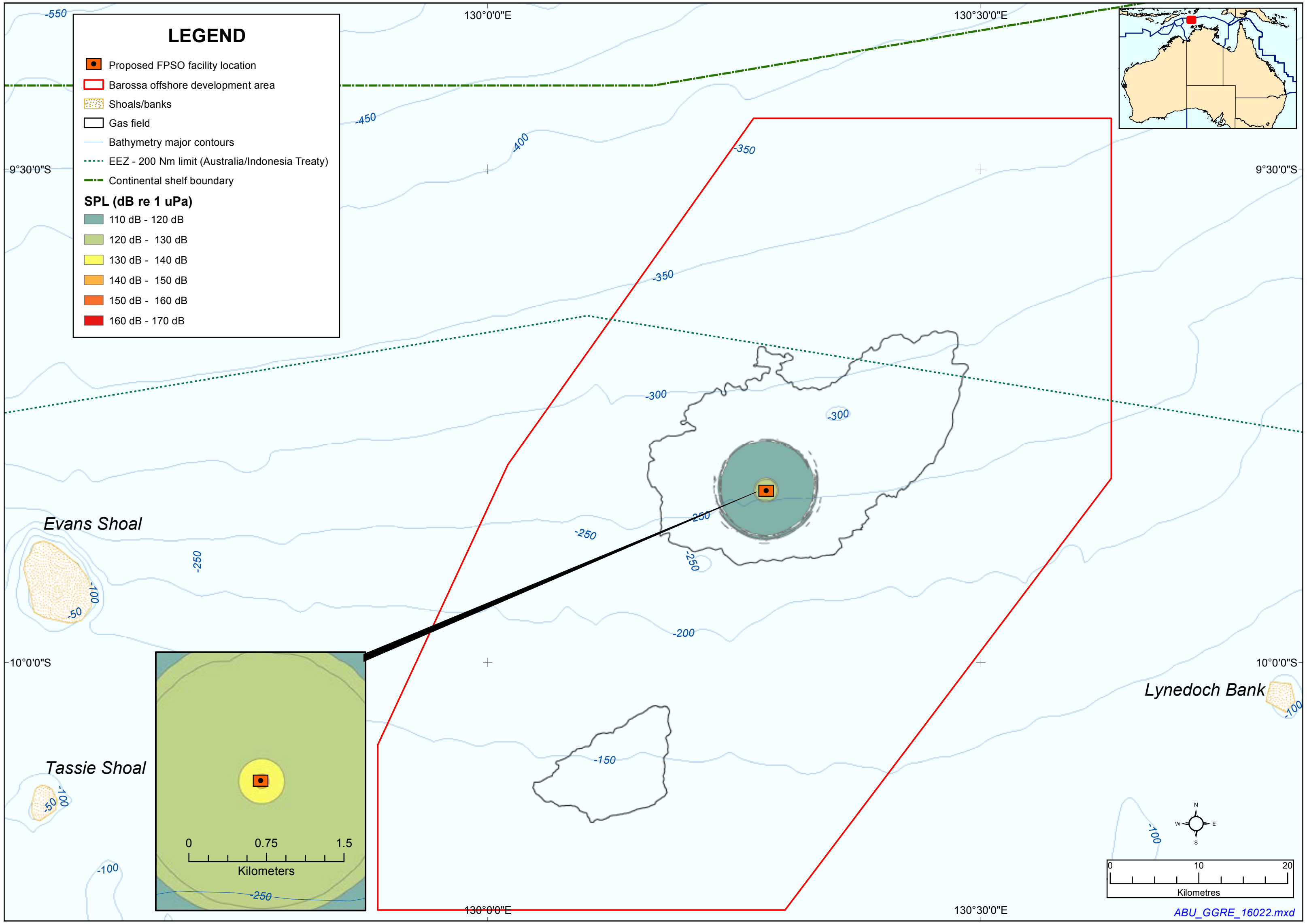


Figure 6-7a: Underwater noise levels from normal operation of the FPSO facility – SPL

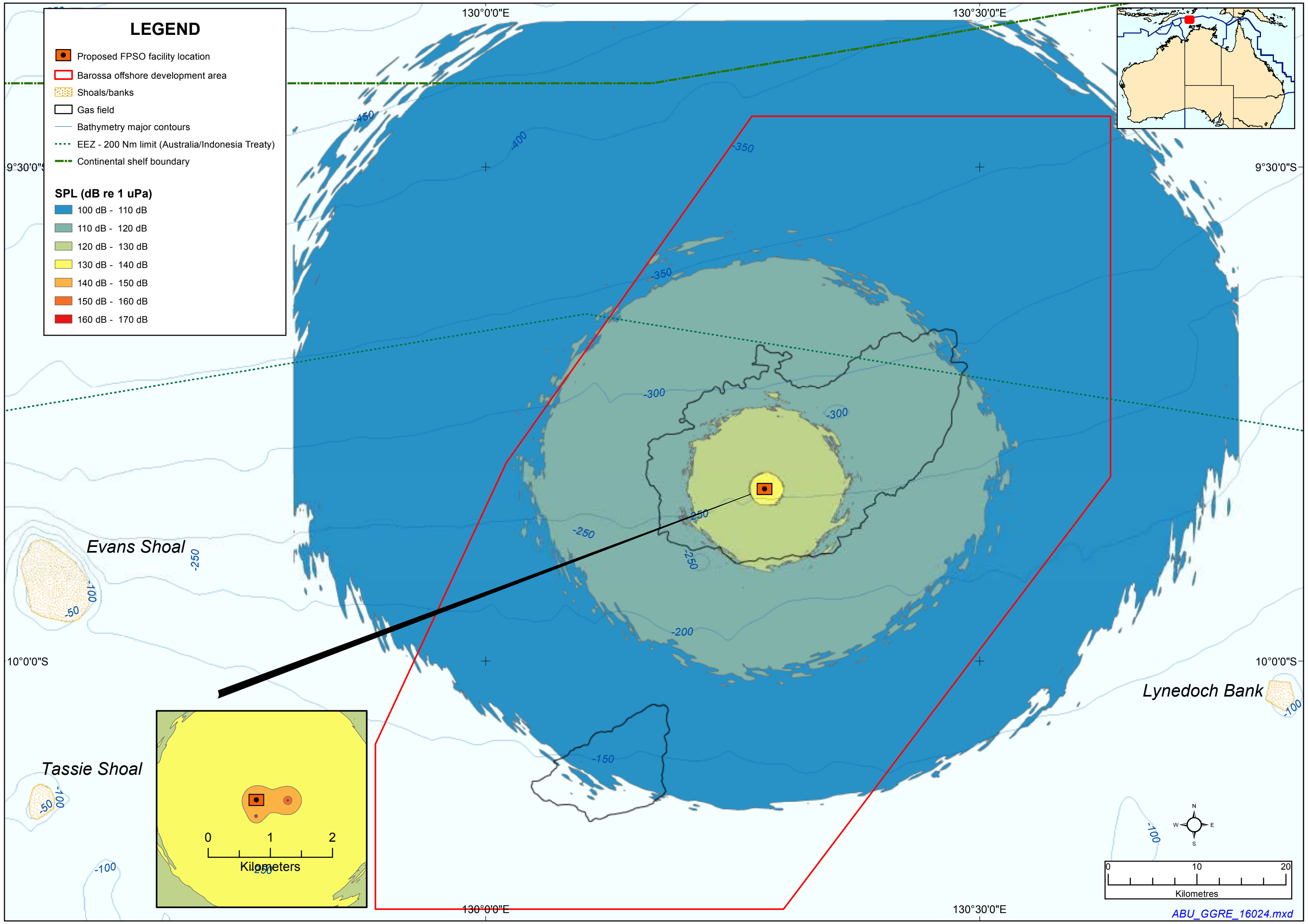


Figure 6-7b: Underwater noise levels from offtake operations (24 hours) of the FPSO facility – SPL

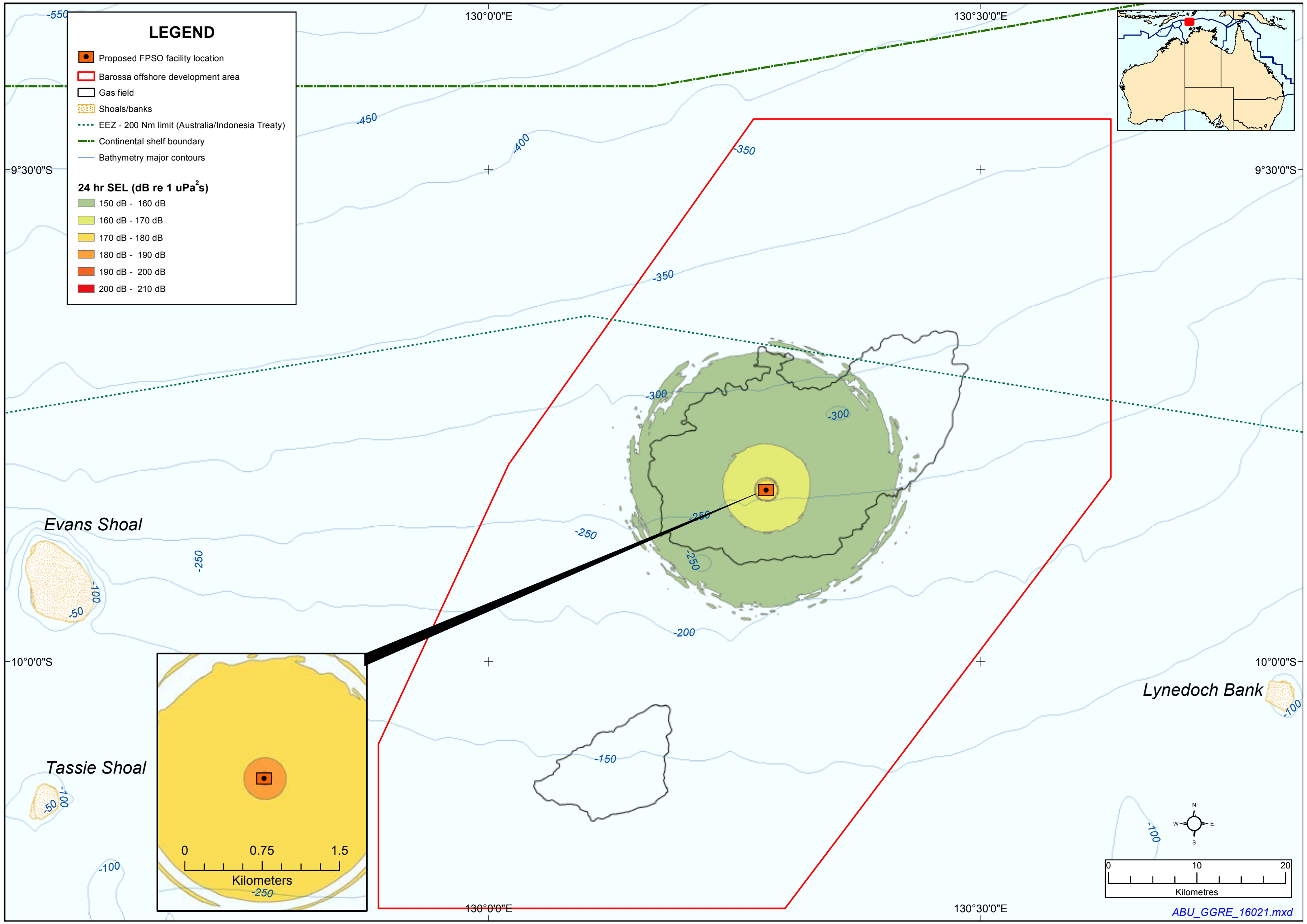


Figure 6-8a: Underwater noise levels from normal operations of the FPSO facility – SEL_{24}

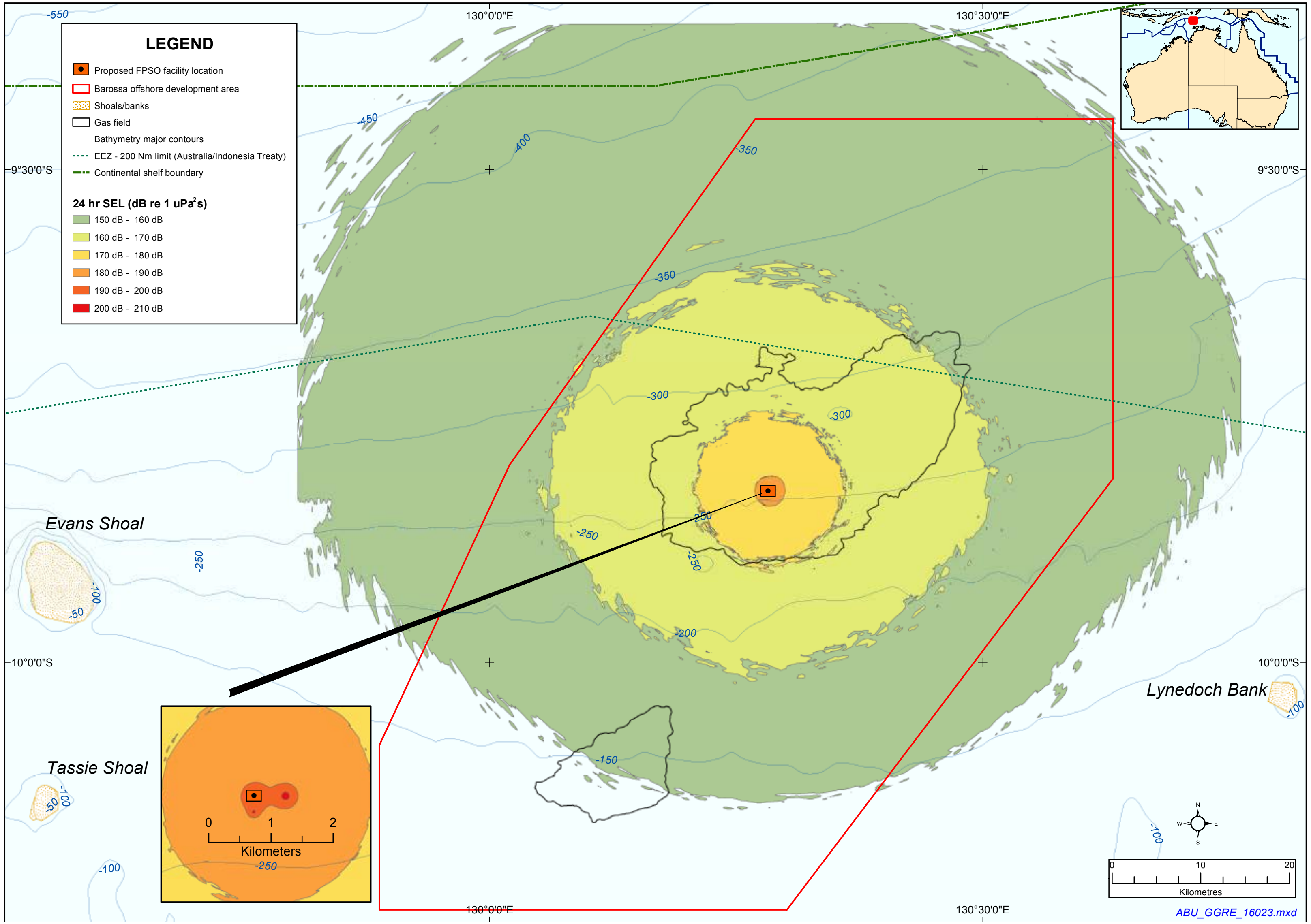


Figure 6-8b: Underwater noise levels from offtake operations (24 hours) of the FPSO facility – SEL_{24}

Impact and risk summary

In conclusion, the residual risk of impact to marine fauna or commercial divers from underwater noise during installation and operations is considered low given the location of the Barossa offshore development area in open offshore waters. There are no significant feeding, breeding or aggregation areas for marine fauna, including nearby shoals and banks, within the predicted area of impact for underwater noise from installation or operations activities within the Barossa offshore development area. Any potential impacts are likely to be restricted to a small number of individuals that may be traversing through the area. Given the localised extent of underwater noise from installation activities associated with the gas export pipeline, the relatively short duration of activities (in the order of 6–12 months) and that the seasonal activity of the flatback and olive ridley turtle internesting period will be taken into account as part of forward scheduling the impacts to individual turtles are expected to be low. No impacts to the catchability of commercial fish species is anticipated as behavioural responses are anticipated to be mostly limited to within close proximity of the source (i.e. within hundreds of metres). The Barossa offshore development area represents a small portion of habitat available to fish populations in the Timor Sea.

The project is considered consistent with the relevant requirements of the Blue Whale Conservation Management Plan, Humpback Whale Recovery Plan 2005-2010 (under review), Recovery Plan for Marine Turtles in Australia and relevant marine fauna species conservation advices as related to underwater noise emissions (**Table 6-25**). A summary of the potential impacts, proposed key management controls, acceptability and EPOs for underwater noise are presented in **Table 6-26**. Proposed key management controls, acceptability and EPOs for underwater noise as related to decommissioning activities are summarised in **Table 7-1**.

Table 6-25: Summary of alignment with relevant EPBC management plans for underwater noise emissions

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)

Marine mammals - Blue whale	Blue Whale Conservation Management Plan (October 2015) (DoE 2015a)	Assess and address anthropogenic noise.	• The impacts from anthropogenic noise have been assessed as low risk given:
			  • there are no significant feeding, breeding or aggregation areas for marine mammals within the predicted area of impact for underwater noise
			  • the results of the assessment of underwater noise from the project demonstrate that the predicted extent of underwater noise emissions affects a very small portion of the offshore waters traversed by marine mammals.
			• Any potential impacts in the project area are likely to restricted to a small number of individuals that may be travelling through the area, and does not present a significant risk to these species at a population level.
			• Mitigation measures to further reduce the risk of anthropogenic noise impacts include:
			  • vessels travelling at relatively low speeds within defined operational areas
			  • project vessels proactively responding to potential fauna interactions in line with the requirements of EPBC Regulations 2000 - Part 8 Division 8.1.
			  • compliance with the requirements of EPBC Act Policy Statement 2.1.
			  • alignment with 'Underwater Piling Noise Guidelines', for pile driving activities.
			Therefore, the requirement to assess and address anthropogenic noise on marine mammals is demonstrated.

Marine mammals - Humpback whale[1]	Humpback Whale Recovery Plan 2005-2010 (May 2005) (under review) (DEH 2005a) Conservation advice (October 2015) (DoE 2015b)	Assess and address anthropogenic noise.	
Marine mammals- Sei whale	Conservation advice (October 2015) (DoE 2015c)	Assess and address anthropogenic noise.	
Marine mammals - Fin whale	Conservation advice (October 2015) (DoE 2015d)	Assessing and addressing anthropogenic noise.	
Marine reptiles – Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (June 2017) (DoEE 2017a)	Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of the species. Manage anthropogenic activities in biologically important areas to ensure that biologically important behaviour can continue. (note, noise interference (acute and chronic) is rated as a moderate threat for the flatback Arafura stock and a low threat for the olive ridley NT stock)	• No significant feeding, breeding or aggregation areas for marine turtles occur within the predicted area of impact for underwater noise in the Barossa offshore development area. • Underwater noise emissions associated with the installation of the gas export pipeline are limited in extent (hundreds of metres within the internesting habitat critical for the survival of flatback and olive ridley turtles) and duration (6–12 months, of which 1-2 months would be within the olive ridley turtle habitat critical for the survival). Therefore, even if a marine turtle was to move from the immediate location of an activity, there is widespread internesting habitat available in the immediate vicinity that marine turtles could continue to use within the identified habitat critical and the potential impacts are not expected to impact biologically important behaviours or prevent those behaviours from occurring. • No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. • Noise interference is not anticipated to result in impacts at a population/genetic stock level. It is concluded that the implementation of management controls will allow the activities to be managed to ensure marine turtles are not displaced from identified habitat critical to the survival of the species and that biologically important behaviour can continue.

[1] Although the species were identified in the EPBC Protected Matters search they are highly unlikely to occur in the project area, which is outside the species range or preferred habitat (see Section 5.6.2 for humpback whales). However, the species may occur within the area of influence.

Table 6-26: Summary of impact assessment, key management controls, acceptability and EPOs for underwater noise emissions

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome

Underwater noise emissions	Marine mammals.
	Marine reptiles.
	Fish.
	Sharks and rays.
		Behavioural disturbance or physiological damage, such as hearing loss, to sensitive marine fauna.
		Masking or interference with marine fauna communications or echolocation.
			The project will be undertaken in accordance with the ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as:
			• the design of offshore facilities/infrastructure to consider engineering measures to minimise operational noise emissions
			• placement of project facilities/infrastructure within the Barossa offshore development area to avoid known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles or shoals/banks.
			Key noise-generating equipment will be maintained in accordance with the manufacturer's specifications, facility planned maintenance system and/or regulatory requirements.
			Any VSP activities conducted at the development well will comply with 'Standard Management Procedures' set out in EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales: Industry Guidelines (DEWHA 2008d) (or the contemporary requirements at the time of the activity), specifically:
			• pre start-up visual observations. Visual observations for the presence of whales by a suitably trained crew member will be carried out at least 30 minutes before the commencement of VSP.
			• start-up and normal operating procedures, including a process for delayed start-up, should whales be sighted. Visual observations by trained crew should be maintained continuously.
			• night time and low visibility procedures.
				The potential impacts and risks associated with underwater noise emissions from the project are considered broadly acceptable given:
				• The residual risk is considered low as:
				  • the location of the Barossa offshore development area is in open offshore waters
				  • there are no significant feeding, breeding or aggregation areas for marine fauna, including nearby shoals and banks, within the predicted area of impact (i.e. within approximately 1.4 km during normal operations and 11.4 km during offtake operations which will occur
				  • any potential impacts in the Barossa offshore development area are likely to restricted to a small number of individuals that may be traversing through the area approximately every 80–100 days) for underwater noise from operations activities within the Barossa offshore development area
					The outer boundary of the planned operational noise footprint (approximately 12 km from source) within the Barossa offshore development area will not impact the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (located > 27 km away).
					The use of FPSO facility thrusters will be limited to that required for safe operations and working requirements.
					No significant adverse impacts to marine fauna populations from VSP operations or pile driving activities.
					No significant impacts to turtle populations from noise generated during installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			If required, pile driving activities will align with the Department of Planning, Transport and Infrastructure (2012) 'Underwater Piling Noise Guidelines' which have been adapted from EPBC Act Policy Statement 2.1 (or the contemporary requirements at the time of the activity). The guidelines include: • safety zones – observation and shutdown zones • standard management and mitigation procedures, e.g. pre-start, soft start, normal operation, stand-by and shut-down procedures • consideration of additional management and mitigation measures, e.g. increased safety zones and marine mammal observers. No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity 60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/ banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	• the localised extent of underwater noise from installation activities associated with the gas export pipeline, the relatively short duration of activities (in the order of 6–12 months) and the control measures in place • behavioural responses of commercial fish species are anticipated to be mostly limited to within close proximity of the source (i.e. within hundreds of metres) • the Barossa offshore development area represents a small portion of habitat available to fish populations in the Timor Sea. • The key management controls are considered effective to manage the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines, ConocoPhillips requirements, applicable management/recovery plans and conservation advices and EPBC Act Policy Statement 2.1. **Table 6-25** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect.	

6.4.6 Atmospheric emissions

The project will generate atmospheric emissions; mainly associated with the combustion of fuel in vessel engines (including the MODU/drill ship) and in the FPSO facility for gas/condensate processing, offshore removal of CO_2 and non-routine flaring due to process upsets or during emergency shut-in of production. The flare system on the FPSO facility provides an important means of pressure relief during emergency shutdowns, process upsets or other unplanned events.

The assessment of potential impacts arising from atmospheric emissions may be considered at a range of spatial scales, and informed by the nature and location of nearest receptors.

The resultant atmospheric emissions from the products of combustion (i.e. including NO_x, sulphur oxides (SO_x), CO, etc.) that may influence local ambient air quality are considered in a local/regional context within this OPP. For this project, given that the offshore location for the Barossa offshore development area is remote and long distances from population centres and key sensitive environmental values and sensitivities, resultant facility emissions are expected to dissipate before reaching any receptors.

Greenhouse gas emissions (GHG) are considered in the context of contributions to Australian and global concentrations at a wider spatial context. ConocoPhillips recognises that the incremental contribution of project-related emissions to Australian and global GHG concentrations is important. Through the forward design and execution of the project, opportunities to minimise GHG emissions will continue to be investigated, as appropriate to the domestic Australian and international policy context at the time.

The risk assessment for potential impacts associated with atmospheric emissions is summarised in **Table 6-27**. For the purpose of this OPP, the basis of the risk assessment is driven by atmospheric emissions affecting local and regional air quality given the context outlined above.

Table 6-27: Atmospheric emissions risk assessment

Risk	Atmospheric and GHG emissions from combustion of fuel for gas/condensate processing, CO_2 removal and non-routine flaring interacting with localised air quality.		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor (associated with vessels during installation and periodic pipeline maintenance/ inspection during operations)		
Key project stage	Development drilling Installation and commissioning Operations		
Key factor(s) (see Table 6-7)	Physical environment (air quality)		
Other relevant factor(s) (see Table 6-7)	-		
Potential impact(s)	• Localised reduction in air quality. • Contribution to the incremental build-up of GHG in the atmosphere.		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	2 Minor (Bio)	1 Improbable	2 Low
Residual risk	2 Minor (Bio)	1 Improbable	2 Low
Confidence	High		

Impact assessment and risk evaluation

Atmospheric and GHG emissions will be produced throughout the life of the project, mainly though the combustion of fuel in the MODU/drill ship and project vessel engines and in the FPSO facility for gas/condensate processing, offshore removal of CO_2 and non-routine flaring (limited). The total net emissions (CO_2-e) from the project are expected to be in the order of 3.4 Mtpa, within a range of 2.1 to 3.8 Mtpa CO_2-e, as summarised in **Section 4.3.5**. Atmospheric emissions of pollutants from products of combustion will result in a minor deterioration in local air quality. Greenhouse gas emissions will cause an incremental increase in domestic and global GHG emissions concentrations, however, they are not considered to have a determinable local-scale impact. Based on latest published data for Australia's National Greenhouse Accounts, Australia's annual total emissions for the year to June 2016 are estimated to be 536.5 Mtpa CO_2-e (Commonwealth of Australia 2016). Therefore, the emissions from the project will represent approximately 0.5–0.7% of the domestic emissions profile.

The greatest gain in emissions efficiency will be through design of offshore facilities/infrastructure, which will investigate engineering measures for practical adoption in order to optimise the energy efficiency of the facilities. The project will comply with all relevant legislation on GHG emissions management, in accordance with the contemporary policy context at the time. The Commonwealth Government currently has in place a Direct Action Plan which is designed to efficiently and effectively source low cost emissions reductions. The Direct Action Plan includes an Emissions Reduction Fund to provide incentives for abatement activities across the Australian economy. As part of the Emissions Reduction Fund, the Government is committed to a Safeguard Mechanism, enacted under the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*, which is administered by the Clean Energy Regulator.

The Safeguard Mechanism sets an appropriate coverage threshold to include facilities with direct emissions of more than 100,000 tonnes CO_2-e a year. It provides for the establishment of baseline emissions numbers for covered facilities to ensure that net covered emissions of GHGs from the operation of a designated large facility do not exceed the baseline applicable to the facility. The project will meet relevant requirements of the *National Greenhouse and Energy Reporting Act 2007*, including the Safeguard Mechanism (or contemporary requirements at the time), as the project progresses.

At this current conceptual stage of engineering definition, it is expected that key opportunities to optimise efficiencies in atmospheric emissions through further design and technology selection may include the consideration of:

- CO_2 permeate re-compression
- CO_2 removal technology
- thermal oxidiser
- power generation turbine selection
- compression turbine selection.

Considering the location of the project in the open ocean, which is well-removed from the nearest residential or sensitive populations on the Tiwi Islands and NT coast, it is considered highly unlikely that local or regional scale atmospheric emissions will result in significant impacts to key values and sensitivities. Measures will be incorporated into project design to achieve energy efficient operations as further engineering definition is available, to minimise GHG emissions where practicable. An evaluation of alternatives to CO_2 management is previously discussed in **Section 4.4.3**.

ODSs have low potential to be present onboard project-related vessels in old refrigeration and air conditioning equipment. Australia, as part of its commitments under the Montreal Protocol, has implemented a successful phase out the use of ODSs, as implemented under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and associated regulations. The release and handling of ODS is not anticipated for any new build infrastructure for the project. ConocoPhillips implements a comprehensive marine vetting process for vessels, which will include screening for project vessels for ODS sources. If required, ODS will be handled in compliance with MARPOL 73/78 Annex VI, Regulation 12 – Ozone-Depleting Substances, and the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and Regulations 1995.

Impact and risk summary

A summary of the potential impacts, proposed key management controls, acceptability and EPOs for atmospheric emissions are presented in **Table 6-28**. In conclusion, the residual risk of impact from atmospheric emissions is considered low given the location of the project in the open ocean, which is well-removed from nearest residential or sensitive populations of the Tiwi Islands or NT coast, the relatively minor contribution (0.5–0.7%) to the domestic GHG emissions profile and the control measures outlined above.

There are no relevant requirements within any EPBC management plans/recovery plans or conservation advices that are of direct relevance to atmospheric emissions.

Table 6-28: Summary of impact assessment, key management controls, acceptability and EPOs for atmospheric emissions

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome

Atmospheric emissions	Physical environment – air quality.	Localised reduction in air quality.
		Contribution to the incremental build-up of GHG in the atmosphere.
			All MODUs/drill ships and vessels (as appropriate to vessel class) will comply with Marine Order 97 (Marine pollution prevention – air pollution), which requires vessels to have a valid IAPP Certificate (for vessels > 400 tonnage) and use of low sulphur diesel fuel, when possible.
			The sulphur content of fuel used by project vessels will comply with Regulation 14 of MARPOL Annex VI (as appropriate to vessel class) in order to control SO_x and particulate matter emissions.
			Fuel gas will be used as the preferred fuel for FPSO processes during operations (instead of diesel or marine gas oil).
			Engineering design of the FPSO facility will seek to reduce atmospheric and GHG emissions through energy efficient design.
			ConocoPhillips will complete and submit annual NGER reports during the operations stage of the project for the Kyoto Protocol listed (or applicable post-Kyoto agreement at the time of operations) GHG emissions on a CO_2 equivalency basis for each facility (as defined in Section 9 of the *National Greenhouse and Energy Reporting Act 2007* and National Greenhouse and Energy Reporting Regulations 2008) by fuel type, and the relevant requirements of the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*.
			GHG and NPI reporting records (or contemporary requirements at the time of the activities) will be complied with during the project for facilities where ConocoPhillips has operational control.
			A preventative maintenance system will be implemented, which includes regular inspections and maintenance of engines and key emission sources and emissions control equipment in accordance with the vendor specifications.
			The requirements of the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and Regulations 1995 will be met, specifically in relation to ODS.
				The potential impacts and risks associated with atmospheric emissions from the project are considered broadly acceptable given:
				• The residual risk is considered low given:
				  ◦ the location of the project in the open ocean, which is well-removed from nearest residential or sensitive populations of the Tiwi Islands or NT coast
				  ◦ the relatively minor contribution (0.5–0.7%) to the domestic GHG emissions profile.
				• The key management measures are considered effective to manage the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks.
				• The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.
				• The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements (e.g. specifically the *National Greenhouse and Energy Reporting Act 2007*, including the Safeguard Mechanism, the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and Regulations 1995, and MARPOL 73/78 Annex VI, Marine Order 97, *National Greenhouse and Energy Reporting Act 2007* and Regulations 2008).
					Atmospheric emissions associated with the project will meet all regulatory source emission standards.
					Engineering design of the FPSO facility will seek to reduce atmospheric and GHG emissions through energy efficient design.
					Combustion engines and flaring equipment will be maintained according to vendor specifications to achieve optimal performance.

6.4.7 Light emissions

Light emissions from the project have the potential to affect marine fauna, particularly marine turtles, migratory seabirds, fish and sharks. The risk assessment for potential for impacts to marine fauna due to light emissions is summarised in **Table 6-29**.

Table 6-29: Light emissions risk assessment

Risk	Light emissions associated with the project interacting with marine fauna, such as marine turtles, migratory seabirds and fish.		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor (associated with vessels during installation and periodic pipeline maintenance/inspection during operations)		
Key project stage	Development drilling Installation and commissioning Operations – presence of the FPSO facility and the requirements for navigational and safety lighting		
Key factor(s) (see Table 6-7)	Marine reptiles	Birds	
Other relevant factor(s) (see Table 6-7)	Marine mammals	Sharks and rays	
	Fish		
Potential impact(s)	• Change in fauna movements and/or behaviour, such as the attraction or disorientation of individuals.		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	3 Moderate (Bio)	1 Improbable	3 Low
Residual risk	3 Moderate (Bio)	1 Improbable	3 Low
Confidence	High		

Impact assessment and risk evaluation

Barossa offshore development area

The FPSO facility and project related vessels (including MODUs/drill ships) will be constantly lit. Functional lighting is required on vessels, MODUs/drill ships and facilities at levels that provide a safe working environment for personnel. Wherever possible (i.e. where not compromising health and safety), lighting will be designed to reduce light overspill. No permanent light sources will be required along the gas export pipeline and the only light emissions proposed will be those associated with vessels during installation, periodic maintenance/inspection and decommissioning activities.

Flaring will occur intermittingly at the facilities during development drilling on the MODU/drill ship (well clean-up), commissioning and operations. The FPSO facility flare system will act to provide pressure relief during emergency shutdowns, process upsets or other unplanned events. Light emissions from flare events will be intermittent and varied in duration. A small pilot flare typically lit during planned operations will not be distinguishable from light from normal operational lighting (**Section 4.3.5.6**). As such, any impacts are expected to be short term and localised to the area surrounding the light source (i.e. MODU/drill ship, FPSO facility or supporting vessels).

Light emissions associated with the project may present a potential risk to marine fauna in the open waters adjacent to the project and cause a temporary change in movement patterns and/or behaviour, such as the attraction or disorientation of individuals.

The impact and risk assessment for light emissions associated with the project has been informed by comparable analogue studies of similar facilities, as detailed below.

A line of sight assessment was undertaken for the Browse FLNG development to determine the maximum distance that direct light may be visible from the FLNG facility (Woodside 2014). The light emissions associated with the FLNG facility are considered to provide a comparative and conservative estimate of light that may be visible from the Barossa FPSO facility. The study predicted that, under planned operational conditions, deck lighting would be visible at receptors above the sea surface at a maximum distance of 18.8 km from the FLNG facility, lighting from the topside modules/cranes a maximum distance of 33.5 km, with the flare visible up to 47.7 km away. It was predicted that should emergency flaring be required, light would be visible up to 57.7 km from the FLNG facility. Considering the results of this study in the context of the Barossa offshore development area, no light from the FPSO facility will be visible from shorelines as the nearest shoreline – the Tiwi Islands – is located approximately 100 km away.

A light density modelling study was also undertaken for the Browse FLNG development to assess the total amount of light received by a surface, as it is recognised that light density decreases within increasing distance from the source. The results of the study predicted that light density levels would attenuate to less than 0.1 Lux (a measure of illuminance) within 5 km of the FLNG facility, which is comparable to light levels associated with a full moon. Light density levels of 0.01 Lux (comparable to light levels from a quarter moon) and less than 0.002 Lux (comparable to a clear to overcast moonless sky) were predicted between 15 km and beyond 33 km from the FLNG facility, respectively (Woodside 2014). The study also considered the likely light density levels from a drill rig (MODU). Light density levels > 0.1 Lux were predicted up to 800 m from the rig, attenuating to levels of 0.01–0.1 Lux (comparable to light levels during a quarter moon to full moon) at 1.2 km from the drill rig (Woodside 2014). Between 1.2 km and 12.6 km, light density levels were predicted to be < 0.01 Lux, which is comparable to light levels between a moonless clear night sky and a quarter moon (Woodside 2014). Beyond 12.6 km from the drill rig, light density levels were modelled as representative of background levels. Taking this study into consideration in the context of the location of the Barossa offshore development area, light associated with the project is not expected to affect any shorelines. Minimal light (levels comparable to between a clear to overcast moonless sky) from the FPSO facility may influence the surface waters above the nearest shoals/banks which are 27 km–35 km.

The potential for marine fauna individuals to be affected by light emissions is limited as the Barossa offshore development area does not contain any significant feeding, breeding or aggregation areas for marine fauna. Therefore, there is likely to be a relatively limited abundance of individuals present in the Barossa offshore development area at any time with individuals likely to be passing through the area. Adult turtles passing through the Barossa offshore development area may temporarily alter their behaviour as a result of being attracted to the light spill from the MODU/drill ship, FPSO facility or vessels. As discussed above, light spill of at least 0.01 Lux (comparable to at least a quarter moon) may extend up to 1.2 km from the drill rig and 15 km from the FPSO facility. Considering the wide distribution of adult turtles outside of nesting season and limited number of individuals likely to be present within the Barossa offshore development area, the potential impact to turtles is expected to be minor and temporary. No impacts to turtle populations are anticipated.

Gas export pipeline corridor

The gas export pipeline corridor is located closer to the Tiwi Islands (approximately 6 km at the closest point), however, there are no permanent light sources associated with this subsea infrastructure. Project vessels will be the only project-related light source within the gas export pipeline corridor during installation, planned operational maintenance and decommissioning activities.

The pipeline corridor lies approximately 6 km from Bathurst Island at the closest point and a pipelay vessel would be directly visible at this distance. The pipelay vessel will be lit at night to provide a safe working environment and to comply with relevant maritime navigation requirements. The pipe welding deck for modern pipelay vessels is typically encased within the vessel structure, reducing light spill to the marine environment when compared to vessels where the welding deck is open. Other areas of the vessel such as cranes and ramps (e.g. pipeline 'stinger') are typically lit for operational safety. Cranes are typically the highest point on pipelay vessels. External lighting on working vessels is often reduced (while maintaining a safe working environment) to promote bridge crew night vision.

Assuming a pipelay vessel height of 65 m (based on the highest point on the pipelay vessel Castorone, one of the largest pipelay vessels currently in commission), line of sight calculations have estimated that the highest point of the vessel will be directly visible from the vessel out to approximately 29 km. It is important to note that this is associated with lighting on the crane, with such lighting often being reduced compared to other enclosed sources of lighting on pipelay vessels.

As outlined above, modelling of light density levels for a drill rig showed that light reduced to levels comparable with a quarter moon to full moon night sky (0.01–0.1 Lux) within 1.2 km, with light density levels equivalent to a moonless clear night sky and a quarter moon sky (< 0.01 Lux) predicted within 12.6 km (Woodside 2014). Given that light emissions from pipelay vessels are more representative of point sources and drill rigs (as opposed to large industrial facilities), it is considered that the pipelay vessel will appear as relatively small lit object on the water's horizon. Any diffuse light glow emitted from the vessel is expected to be minimal on the Tiwi Islands coastline and largely insignificant as it would be comparable to the light level on a moonless clear night sky and a quarter moon sky. It is also expected that the temporary presence of the pipelay vessels in the area will not significantly increase the volume of vessel traffic that operates in the area. Data from the Australian Maritime Safety Authority's (AMSA's) craft tracking system indicates considerable vessel traffic routinely moving from the port of Darwin, with vessels moving north routinely navigating around the western tip of Bathurst Island at distances from shore consistent with the closest point of the pipeline corridor (**Figure 5-26**). These are typically commercial vessels (e.g. container vessels, tankers, etc.) moving to and from ports throughout south-east Asia. During the installation period, the pipelay vessel will continuously traverse along the pipeline alignment (i.e. not a stationary vessel), therefore the small area of light spill will not impact any one location for an extended duration and is not expected to have any impacts additional to existing vessel traffic traversing the area.

Light impacts to internesting flatback and olive ridley turtles are of particular relevance to this impact assessment, given the fact that the pipeline corridor intersects internesting habitat critical to the survival of flatback and olive ridley turtles (**Figure 5-14**) and is adjacent to the internesting BIA for olive ridley turtles. The percentage proportion of the internesting habitat critical to the survival of flatback and olive ridley turtles that is intersected by the gas export pipeline corridor is 3.7% and 3.2%, respectively. However, the actual area likely to be affected by light emissions during pipeline installation at any one time will be considerably smaller given the reality that the area of disturbance will be based on a vessel slowly moving along a defined pipeline route. There is no evidence, published or anecdotal to suggest internesting turtles are impacted by light from offshore vessels, and nothing in their biology would indicate this is a plausible threat (Pendoley 2017; **Appendix Q**, Witherington and Martin 2003). Light spill is likely to be localised to within a few kilometres of the pipeline installation activity, and the internesting turtle population are exposed to existing light spill from shipping activities using the area between the gas export pipeline corridor and the Tiwi Islands as a channel for entry/exit to Darwin Harbour (**Figure 5-26**). The number of internesting turtles potentially exposed to the pipeline operations over a 6–12 month period during installation is low given the peak internesting period (June to September for flatbacks and April to August for olive ridley turtles) is a subset of the installation period.

As discussed in **Section 6.4.3**, taking into account the outcomes of a professional review by Pendoley (2017; Appendix Q), as well as a number of other studies investigating internesting behaviours of flatback and olive ridley turtles (**Section 5.6.3**), the 30 m depth contour is considered to encompass the vast majority of the area that flatback and olive ridley turtles would undertake internesting activities (i.e. resting on the seabed), with the existing 24 nm (44.5 km) Contiguous Zone Boundary encompassing the extent (waters up to 55 m deep) that internesting turtles are likely to extend to (Pendoley 2017). These studies have demonstrated that while turtles may be present in offshore waters with water depths of up 55 m during the internesting period, they are typically freely moving through these areas before they return to shallow waters (less than 30 m deep and typically shallower than 10 m) to rest in the days leading up to re-nesting activity. The area in which internesting behaviours occur (i.e. resting in waters less than 30 m deep prior to re-nesting) does not intersect the majority of the gas export pipeline corridor, the broader area that is traversed by internesting turtles (i.e. waters up to 55 m deep) occupies a portion of the gas export pipeline corridor. If the final pipeline route remains outside of the Oceanic Shoals marine park in the shallow water area, then some overlap with water depths (< 30 m) within which marine turtles may exhibit internesting activities would occur. However, the vast majority of suitable internesting habitat and remains outside the corridor and available for internesting turtles. In summary, light from installation vessels is unlikely to have a significant effect on individual internesting marine turtles transiting the area given the relatively short-term nature of the activities (approximately 6–12 months).

Studies in other areas have shown that artificial lighting may affect the location that nesting turtles emerge to the beach, the success of nest construction, whether nesting is abandoned, and the seaward return of adults (Salmon et al. 1995, Salmon and Witherington 1995). Studies of nesting inhibition of female turtles have demonstrated a clear effect of direct lighting on turtle nesting beaches, with artificial lighting appearing to deter females from leaving the water (Witherington and Martin 2000). The source of lighting in such studies has typically been from residential and industrial development overlapping the coastline, rather than offshore from nesting beaches. The potential for nesting female turtles to be inhibited by artificial light emissions from a pipelay vessel is low when considering the distance of the light source from the beach and observed behavioural responses elsewhere, and the fact that turtles continue to successfully nest on the Tiwi Islands in the presence of light from existing vessel traffic in the area.

The primary light sensitive receptors in the gas export pipeline corridor of particular relevance are hatchling flatback and olive ridley turtles located on the shores of the Tiwi Islands. Hatchlings emerging from the sand locate the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon and away from elevated silhouettes of dunes and/or vegetation bordering the beach on the landward side (Limpus 1971, Salmon et al. 1992, Limpus and Kamrowski 2013, Pendoley and Kamrowski 2016). Artificial light from onshore coastal developments has been demonstrated to cause disorientation of hatchling turtles during the post-hatching movements (Lorne and Salmon 2007, Salmon 2003, Tuxbury and Salmon 2005). Salmon (2003) identified two distinct behavioural responses of hatchling turtles exposed to artificial light after emerging from the nest:

- Misorientation – misorientation occurs when hatchling turtles orientate towards artificial light sources instead of directly towards the ocean; and
- Disorientation – disorientation occurs when turtle hatchlings crawl in circuitous paths, often near artificial light sources.

Turtles disoriented or misoriented by artificial lighting may take longer, or fail, to reach the sea. This may result in increased mortality through dehydration, predation or exhaustion (Salmon and Witherington 1995).

While some studies have shown hatchling orientation to be disrupted by light produced at distances of up to 18 km from the nesting beach this has been from large onshore coastal industrial facilities (Hodge et al. 2007 in Pendoley 2017), not offshore sources. Other studies have demonstrated that diffuse light glow from these light sources does not cause hatchling disorientation beyond 4.8 km from the light source (Limpus 2006) and individual lights as point sources have been reported to disorient hatchling turtles up to a few hundred metres (Limpus 2006). The impact observed by Hodge et al. (2007) (cited in Pendoley 2017) was limited to misorientation, with hatchling turtles taking a slightly longer path to reach the sea. The light source was a large industrial installation (the Boyne Island alumina smelter), which is considerably larger and has much higher levels and intensity of light emissions than a typical pipelay vessel. While the work of Hodge et al. (2007) provides evidence of potential impacts of artificial light from large industrial facilities on hatchling turtle behaviour, caution should be used in making inferences about light sources that differ in nature and scale.

Based on the range at which a typical pipelay vessel may be visible, vessels in the majority of the pipelay corridor will not be directly observable from the shore. In the event hatchling turtles from nests on the Tiwi Islands became oriented toward light emissions from the pipelay vessels, it is unlikely that this behavioural response would prevent hatchlings reaching the sea given the pipeline corridor is directly west of the Tiwi Islands. Light-induced impacts on hatchlings turtles between exiting the nest and reaching the sea (e.g. dehydration, exhaustion and predation by terrestrial predators) would be highly unlikely to be increased compared to if the pipelay vessel was absent. Given the source of the light is seaward of the nesting beach, it would be highly unlikely to disorientate hatchlings to a degree that would reduce their ability to locate and orientate towards the ocean.

Once hatchlings enter the ocean, an internal compass set while crawling down the beach, together with wave cues, are used to reliably guide them offshore (Lohmann and Lohmann 1992, Stapput and Wiltschko 2005). Water movement has been shown to be an important influence on hatchling turtles, with hatchlings swimming directly towards oncoming waves (Lohmann et al. 1990, Lohmann and Lohmann 1992). In the absence of wave cues however, swimming hatchlings have been shown to orient towards light cues (Lorne and Salmon 2007, Harewood and Horrocks 2008), and over short distances of up to 150 m, hatchlings are more influenced by light than wave cues (i.e. the light cue overrode the wave cue at this distance). Once in the sea, hatchlings of most marine turtle species assume a pelagic life history phase. A notable exception is flatback turtle hatchlings, which do not have a pelagic phase, instead residing in coastal shallow waters on the continental shelf (Pendoley 2017).

Hatchlings are not trapped indefinitely in light pools and eventually continue the migration offshore (Thums et al. 2013, 2016). However, they may be exposed to an increased risk of predation when trapped in light spill from vessels. Overnight observations of flatback turtle hatchlings trapped by the light spill from a pipelay barge moored approximately 10 km off the east coast of Barrow Island found hatchlings remained within the light spill in the lee of the barge all night until dawn when they swam away from the barge and were carried away by currents (K. Pendoley pers. comm. 2003). None of the monitored hatchlings were predated. These observations, together with experimental results that demonstrated the attraction of hatchlings to light at sea over 150 m (Thums et al. 2016), suggests that hatchlings carried by currents into the vicinity (estimated 500 m–1,000 m) of a pipelay barge can become trapped by light (Pendoley 2017). While hatchling turtles in the sea are attracted to artificial lights, the influence on turtle behavior and impact to hatchlings was considerably less compared to the effects of light on hatchlings on the shoreline. The results of this study indicated that hatchling turtles were misoriented towards artificial light once entering the sea, however, the misorientation did not result in disorientation. The presence of artificial light in the study did not prohibit hatchling turtles from migrating offshore, but did result in hatchling turtles spending a greater period during night hours in areas of the sea illuminated by artificial light compared to non-illuminated conditions. Thums et al. (2016) suggested that the increased time spent by hatchlings in artificially illuminated areas at sea may increase the risk of predation. Of the 40 hatchlings tagged during the study, Thums et al. (2016) suggested one may have been predated. It is of note that the artificial light source used in the study was intense (400 W metal halide light), directed towards the natal beach, and located approximately 200-300 m from the beach. This is not consistent with the potential light emitted from the pipelay vessel, which will be over 6 km from the nearest nesting beach at the closest possible point within the pipeline corridor. At this distance, the illumination perceived by hatchling turtles on the nearest beaches on the Tiwi Islands with be considerably less intense, comparable to the light level on a moonless clear night sky and a quarter moon sky, and therefore, is unlikely to have the same effect.

The risk of trapping and possible increased risk of predation is greatest in the southern end of the pipeline corridor where it passes at its closest point to Bathurst Island off Cape Fourcroy. The risk of this occurring is considered relatively low when taking into account: the limited time the pipelay vessel and associated support vessel will be present at any one location off the west coast of the Tiwi Islands, the temporally restricted peak hatchling season (June – September for flatback turtles and April – August for olive ridley turtles), the low risk of hatchlings intersecting a small zone (approximately 500 m–1,000 m) around the pipelay vessel over which they might be influenced to orient towards the vessel lights, the currents in the area mean there is a low likelihood the hatchlings will be in slow moving water (< 0.5 knots) that would allow them to swim against a current towards the light source and then remain in the light, and the short (overnight) time frame the hatchlings could be trapped. Any hatchlings that do become trapped in the light spill from a vessel may be at risk from an increased risk of predation, however, the risk of this is likely reduced due to the distance offshore from predator rich inshore waters. The risk to the flatback and olive ridley turtle populations from the light spill during pipelay installation activities is therefore considered to be low and undetectable against normal population fluctuations.

An assessment against the significance impact criteria in the Significant Impact Guidelines 1.1 – Matters of National Environmental Significance is provided in **Appendix Q**. The installation of the Barossa gas export pipeline at any time of year is not expected to represent a significant risk to flatback and olive ridley turtles at a population level, taking into consideration:

- No pipeline installation activities will occur at any time (including peak hatchling and emergence periods) within the olive ridley turtle internesting BIA
- the relatively short 6–12 month time frame of the pipeline installation is insignificant within the context of the long breeding period of marine turtles and so the time frame the breeding females are potentially exposed to the project is low
- pipelay vessels are mobile and will not be on any one location for extended periods of time. Any exposure of internesting females or dispersing hatchlings to project related risk will be temporary.
- the seasonally dispersed nesting behaviour reduces the risk of exposure to the entire breeding population
- while migrating offshore, hatchlings will be dispersed by currents across large areas of ocean, under the influence of tides and currents which will reduce the opportunity for individuals to intercept or pool around a vessel
- hatchlings are unable to swim against fast moving tides and currents and a few individuals might be trapped by light spill from a vessel if they are carried directly to the vessel location by tides or currents
- hatchlings will only be able to engage in directional swimming (i.e. to actively swim directly towards a vessel light) during the few hours a day when water speeds are very slow or at slack water and will be swept away as the tide gains strength. The number of individuals potentially impacted are expected to be low.

In summary, the impact evaluation demonstrates that impacts to turtles from light during pipeline installation at any time of year are not anticipated to result in impacts at a population level, with the risk to the marine turtle populations from the proposed pipeline installation considered to be low and undetectable against normal population fluctuations. Determinable impacts at a population level from temporary and localised changes in internesting habitat critical to the survival of flatback and olive ridley turtles are not expected given the fact that the light emitted from project vessels will only affect turtles present within a small portion of the available internesting habitat critical to the survival of these species. With regard to potential impacts to hatchlings, individual female turtles also generally do not breed each year. For example, flatback turtles have been observed to breed at intervals between one to five years (mean of 2.7 years) (DoEE 2017e). Olive ridley turtles, however, differ to the other marine turtle species in that the majority (over 60%) of females nest every year (IUCN 2017). Taking this into account, the likelihood of population level impacts is further reduced as it is unlikely that the entire population will be nesting/internesting in any one season. The implementation of key management controls will provide for acceptable environmental outcomes, taking into account the short-term transient nature of effects during the pipeline activities.

Studies have shown that sea snakes display varying responses to light. For example, *Hydrophine* species appear to be attracted to light and have been observed floating on the sea surface and swimming up to light (pers. comm. M. Guinea, CDU, 2014). However, the *Aispysurus* species of sea snake do not appear to be attracted to light and are not seen on the surface at night (pers. comm. M. Guinea, CDU, 2014). The majority of sea snakes are likely to be associated with the offshore shoals/banks in the Timor Sea, with the closest bank to the Barossa offshore development area being Lynedoch Bank, which is approximately 27 km to the south-east. There are a couple of shoals/banks in close proximity to the gas export pipeline corridor. It is recognised that some pelagic sea snake individuals (*Pelamis* genus) may occur in the vicinity of the project area and may be attracted to the light from the project. However, while such individuals may come to investigate the light source, it is considered unlikely that they will stay within the area (pers. comm. M. Guinea, CDU, 2014). In addition, as mentioned above, there are no permanent light sources proposed along the gas export pipeline.

A number of migratory bird species may transit the project area along their migratory pathway, as outlined in **Table 5-4**. Research indicates that seabirds may be attracted to artificial light, thereby possibly affecting migration patterns, and could potentially collide with infrastructure and flares. In general, the impacts are considered to be dependent on weather conditions. During clear weather conditions, well-lit offshore structures have minimal or no impact on avifauna. Offshore structures can actually provide additional roosting sites for species flying through the area. During conditions of persistent light rain fog or mist, which are unusual events in the Timor Sea, the reflectance of light from offshore structures is increased, compounding the disorientation effects of avifauna and potentially resulting in high mortalities due to collision with structures. The likelihood and frequency of such events leading to significant mortalities in the Timor Sea are considered low as such events are unusual and generally localised. Furthermore, artificial light from the Barossa offshore development area is unlikely to attract a significant number of individuals considering the vast distance to key feeding, breeding or aggregation areas, such as the Tiwi Islands (100 km), Ashmore Reef (750 km) and Cartier Island (735 km).

Studies in the North Sea indicate that migratory birds are attracted to lights on offshore platforms when travelling within a radius of 5 km from the light source while outside this zone their migratory paths are unaffected (Shell 2009). Given the relatively small number of transiting individuals passing within the vicinity of the project area relative to the extensive scale of the East Asian-Australasian Flyway, any behavioural effects such as disorientation or attraction, or mortality from collisions are expected to be minor.

Migratory shorebirds, such as the red knot, do not typically interact with the sea surface and do not generally land on man-made structures, such as the facilities proposed for the Barossa offshore development area, in significant numbers (pers. comm. R. Clarke, Monash University, 2016). Given the distances to the nearest emergent shorelines (where these migratory species breed, forage and rest) from the Barossa offshore development area, impacts on these species from light are considered unlikely. Migratory shorebirds are also unlikely to interact with the pipelay vessels during the installation of the gas export pipeline given the limited nature of the light emissions.

A BIA for the crested tern, a migratory seabird, has been designated at the northern tip of Melville Island including a 20 km buffer from the breeding shoreline of Seagull Island noted as a foraging zone (DoEE 2017c). Light emissions from the pipelay installation vessels are not anticipated to impact the breeding population of crested terns located on the shoreline of Seagull Island given its distance from the light sources on project vessels (> 19 km). Impacts to species foraging within the 20 km buffer are unlikely to be disorientated by light emissions given the scale of lighting required for pipelay vessels, the relatively short term nature of the activity (in the order of 6–12 months) and their pre-existing exposure to other anthropogenic light sources in the surrounding area (e.g. adjacent shipping activities; **Figure 5-26**).

There are no areas of biological importance recognised in the NMR for whale sharks. Due to their widespread distribution and highly migratory nature, whale sharks may occur — albeit in very low numbers — in the Barossa offshore development area and northern end of the gas export pipeline. Therefore, light impacts to whale sharks from the Barossa offshore development area and vessels during pipeline installation will not occur at a population level and are expected to be negligible to individuals transiting the area.

Sharks and rays identified as potentially occurring in the project area typically inhabit nearshore coastal waters (e.g. green sawfish, largetooth sawfish, dwarf sawfish, speartooth shark, northern river shark, reef manta ray and giant manta ray). While individuals (e.g. great white and mako sharks) may transit the open ocean environments surrounding the Barossa offshore development and gas export pipeline areas, impacts from light will not result in population level effects and will not extend to any areas of biological importance for these species.

Impact and risk summary

In conclusion, the residual risk of impact to marine fauna from light emissions during installation and operations in the Barossa offshore development area is considered low given the predicted area of influence from lighting does not contain any significant feeding, breeding or aggregation areas for marine fauna, or emergent shorelines. Minimal light (levels comparable to between a clear to overcast moonless sky) influencing the surface waters above the nearest shoals/banks is not anticipated to significantly impact marine fauna at these locations. Light impacts to marine fauna within the vicinity of the gas export pipeline corridor during pipeline installation (in particular flatback and olive ridley turtles, and the crested tern) are anticipated to be minor given the distance from emergent shorelines on the Tiwi Islands where turtle and crested tern nesting areas are located (approximately > 6 km), and the consideration of seasonal presence/ activity in the installation of the gas export pipeline.

The project is considered consistent with the relevant requirements of the Recovery Plan for Marine Turtles in Australia and species conservation advices as related to light emissions (**Table 6-30**). A summary of the potential impacts, proposed key management controls, acceptability and EPOs for light emissions are presented in **Table 6-31**.

Table 6-30: Summary of alignment with relevant EPBC management plans for light emissions

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Marine reptiles - Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (June 2017) (DoEE 2017a)	Minimise light pollution.	• External lighting on offshore facilities/infrastructure will be minimised to that required for navigation.
		Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats.	• There are no regionally significant feeding, breeding or aggregation areas for turtles within the Barossa offshore development area. • No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. • Light spill from the pipelay vessels is expected to be largely insignificant on the Tiwi Islands where hatchlings are most susceptible (i.e. light spill will be comparable to the light level on a moonless clear night sky and a quarter moon sky).
		Manage anthropogenic activities in biologically important areas to ensure that biologically important behaviour can continue.	• The risk of hatchlings becoming trapped by light (and therefore being predated upon) is low given the limited time the pipelay vessel will be in any one location, the restricted peak hatchling season, the small zone over which hatchlings may orient towards the vessel lights (500 m–1,000 m of a pipelay barge), the currents in the area are likely to be stronger than the hatchlings swimming ability (either to swim to the light and/or remain there), and the short (overnight at most) timeframe the hatchlings could be trapped if not moved on by currents. • There is no evidence that suggests internesting and nesting turtles are impacted by light from offshore vessels, and nothing in their biology would indicate this is a plausible threat. • The short term/temporary presence of the pipelay vessels in the area will not significantly increase the volume of existing commercial shipping traffic in the area. • Given that light emitted from project vessels will only affect a small portion of the internesting BIA/habitat critical for the survival of these species, even if a marine turtle was to move from the immediate location of an activity, there is widespread internesting habitat available in the immediate vicinity that marine turtles could continue to use within the identified habitat critical and the potential impacts are not expected to impact biologically important behaviours or prevent those behaviours from occurring. • An assessment against the significance impact criteria in DoEE's Significant Impact Guidelines 1.1 – Matters of National Environmental Significance concluded that the installation of the gas export pipeline is not expected to represent a significant risk to flatback and olive ridley turtles at a population/stock level given the relatively short installation timeframe, the mobility of the pipelay vessels, seasonally dispersed nesting behaviour and large ocean currents which reduce the ability of hatchlings to intercept or pool around the vessel. It is concluded that the implementation of management controls will allow the activities to be managed to ensure marine turtles are not displaced from identified habitat critical to their survival and that biologically important behaviour can continue.
Birds – Red knot	Conservation advice (May 2016) (DoE 2016f)	No specific actions or requirements are identified for disturbance from night lighting.	• There are no regionally significant feeding, breeding or aggregation areas for the red knot within the project area. • The short term/temporary presence of the pipelay vessels in the area will not significantly increase the volume of light emitted from existing commercial shipping traffic in the area. • External lighting on offshore facilities/infrastructure will be minimised to that required for navigation, safety and safety of deck operations, except in the case of an emergency.

Table 6-31: Summary of impact assessment, key management controls, acceptability and EPOs for light emissions

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
Light emissions	Marine reptiles. Birds.	Change in fauna movements and/ or behaviour, such as the attraction or disorientation of individuals.	All vessels in Australian waters adhere to the navigation safety requirements contained within COLREGS, Chapter 5 of SOLAS, the *Navigation Act 2012* and subordinate Marine Order 30 (Prevention of Collisions) (as appropriate to vessel class) with respect to navigation and workplace safety equipment (including lighting). IALA Recommendation O-139 on The Marking of Man-Made Offshore Structures will be followed. External lighting on offshore facilities/infrastructure will be minimised to that required for navigation, safety and safety of deck operations, except in the case of an emergency. No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. Installation schedule of the gas export pipeline will take into consideration seasonal presence/ activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1 identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP	The potential impacts and risks associated with light emissions from the project are considered broadly acceptable given: • The residual risk is considered low as: • the predicted area of influence from lighting within the Barossa offshore development area does not contain any significant feeding, breeding or aggregation areas for marine fauna, or emergent shorelines • minimal light (levels comparable to between a quarter and full moon) influencing the surface waters above the nearest shoals/banks from the Barossa offshore development area (located 27 km–35 km away) is not anticipated to significantly impact marine fauna at these locations	Light spill from the MODUs/drill ships, FPSO facility and project vessels will be limited to that required for safe operations and working requirements. No significant impacts to turtle populations from installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	• light impacts to marine fauna within the vicinity of the gas export pipeline (in particular turtles and the crested tern) are anticipated to be minor given the distance (> 6 km) from emergent shorelines on the Tiwi Islands where turtle hatchlings and crested tern nesting areas are located no permanent light sources are required along the gas export pipeline • no permanent light sources are required along the gas export pipeline. • The key management measures are considered effective to manage the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements and applicable recovery plans and conservation advices. **Table 6-30** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect.	

6.4.8 Planned discharges

Over the course of the project life-cycle, a number of planned discharges to the marine environment will be required (as outlined in **Section 4**) and will include drill cuttings and fluids, PW, cooling water, wastewater, flooding fluid from dewatering and brine. These planned discharges are typical of, and consistent with, those associated with offshore oil and gas facilities in terms of their nature, volume and duration and have been used to inform the impact assessment presented in this OPP. These discharges are considered representative of the outer envelope that may be routinely influenced by the project and allow all potential impacts and risks to the marine environment to be assessed. As described in **Section 4**, other small planned discharges may occur during the project, such as hydraulic fluids from the BOP and excess cement during development drilling, well testing and completion fluids during pre-commissioning and testing activities, lubrication oil from planned maintenance of in-field subsea infrastructure, or corrosion inhibitor/inhibited seawater or MEG from the pig receiver located at the gas export pipeline tie-in location during pigging activities. However, these discharges will be for a short duration (instantaneous) and, given the small volumes, will be localised in scale. Therefore, as noted above, any potential impacts are expected to occur within the area influenced by the larger planned discharges. The full range of potential planned discharge sources that may be associated with the different stages of the project will be further assessed and defined as the engineering design progresses and detailed in activity-specific EPs.

All planned discharges associated with the project will be managed to meet relevant legislative requirements and ConocoPhillips' standards.

The risk assessment for potential impacts to the marine environment is summarised in **Table 6-32**.

Table 6-32: Planned discharges risk assessment

Risk	Impacts to the marine environment from planned discharges, such as drill cuttings and fluids, PW, cooling water, dewatering of flooding fluid and vessel overboard discharges (e.g. brine and wastewater).		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor (installation and pre-commissioning)		
Key project stage	All – particularly operations (Barossa offshore development area)		
Key factor(s) (see Table 6-7)	Physical environment (water quality, sediment quality)	KEFs	
	Shoals and banks		
Other relevant factor(s) (see Table 6-7)	Marine mammals	Fish	
	Marine reptiles	Sharks and rays	
	Birds		
Potential impact(s)	• Localised and temporary reduction in water quality associated with increased turbidity, water temperature or salinity leading to impacts to marine fauna. • Localised displacement, smothering (mainly associated with discharge of drill fluids and cuttings) or toxicity of benthic habitats/communities that are regionally widespread.		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	3 Moderate (Bio)	1 Improbable	3 Low
Residual risk	3 Moderate (Bio)	1 Improbable	3 Low
Confidence	High		

Impact assessment and risk evaluation

A number of planned discharges to the marine environment will be required throughout the life of the project and will include drill cuttings and fluids, PW, cooling water, wastewater, dewatering of flooding fluid and brine. The key planned discharge sources include the FPSO facility and project vessels (including MODUs/ drill ships).

Planned discharges have the potential to cause a localised and temporary reduction in water quality that could result in indirect impacts to marine fauna that may be present in the project area. Further discussion of the potential impacts to the marine environment, as relevant to the key discharge streams and informed by detailed modelling, is provided in **Section 6.4.8.2** to **Section 6.4.8.7**.

6.4.8.1 Overview of planned discharge modelling

Discharge modelling was undertaken by RPS APASA (2012, 2017a-d) for the key planned discharges to the marine environment associated with the project, including drill cuttings and fluids, PW, cooling water, wastewater and flooding fluid from dewatering of the gas export pipeline. The planned discharges were modelled as point sources from:

- a potential MODU/drill ship location, in closest proximity to the nearest shoals/banks – for drill cuttings and fluids only
- the FPSO facility (conservative location[5]) – for PW, cooling water and wastewater discharges
- the riser base manifold (located at the FPSO facility location) – for dewatering of flooding fluid from thegas export pipeline.

Drill cuttings and fluids modelling were undertaken for both discharges directly to the seabed and at the sea surface. Modelling of PW, cooling water and wastewater discharges were undertaken from an approximate source depth of 10 m below the mean sea level, as informed by early engineering information. Dewatering discharge modelling was undertaken from an approximate depth of 3.5 m above the seafloor at the proposed riser base manifold location.

The RPS APASA discharge models took into consideration regional tidal currents, as informed by the HYDROMAP model which has been thoroughly tested and verified by field measurements collected around the globe (Isaji and Spaulding 1984; Isaji et al. 2001; Zigic et al. 2003, cited in APASA 2012 and RPS 2017a-e), and large-scale ocean currents. To account for the natural annual and seasonal variation of oceanographic conditions, modelling of the PW, cooling water, wastewater and flooding fluid dewatering discharges was undertaken for each month for three years (2010, 2012 and 2014, to represent a La Niña weather event, a neutral (mixed) and El Niño year respectively), with results reported on a combined seasonal basis (i.e. summer, winter and the transitional periods). Modelling of the drill cuttings and fluids considered each month of the 2004 ocean current data as it included periods where strong ocean currents travelled towards the nearest shoals, thereby providing a conservative assessment of potential sediment deposition (APASA 2012). The current data and discharge characteristics were then added into advanced three-dimensional models to predict the movement and settlement/dilution of the planned discharges.

The modelling of operational discharges considered the data collected during the extensive and robust Barossa marine studies program to validate the hydrodynamic model (**Section 5.2**). These data are considered the most accurate for this particular region and have been used to validate the models applied and provide confirmation of accuracy with regard to inputs of currents, winds and depth profiles of water temperature and salinity (RPS 2017a-e). As a result of the validation process, the models and inputs used by RPS APASA to inform the modelling are considered best available and highly representative of the characteristics influencing the marine environment, particularly within the Barossa offshore development area, and provide high confidence in the modelling outputs (RPS APASA 2015).

The modelling provides an accurate representation of the key characteristics and volumes of the planned discharges associated with the project, given the current engineering definition. Modelling was completed to evaluate the maximum area that could be affected by these planned discharges and, therefore, assess potential impacts to the marine environment, particularly to the immediate receiving open ocean waters and closest shoals/banks. Therefore, the discharge modelling scenarios have informed the overall determination of environmental consequence and acceptability for the project in relation to planned discharges. It is recognised that other specific planned discharges may be identified which require modelling as activity-specific discharge stream characteristics are better defined as design and execution planning progresses, and these will be assessed in activity-specific EPs. The specific planned discharges in the Barossa offshore development area are expected be within the area of influence defined in this OPP.

The key modelling parameters, assumptions, results and conclusions in relation to the key values and sensitivities are summarised in **Section 6.4.8.2** to **Section 6.4.8.5** below. These sections also assess the potential impacts and risks to the marine environment, with detailed consideration of the planned discharge modelling outputs.

[5] As the project is still in the early design phase, the location of the FPSO facility (as shown in **Figure 4-2**) is indicative and may be subject to refinement as engineering design progresses. Therefore, for the purposes of the modelling a conservative location closest to the nearest shoals/banks of Evans Shoal and Tassie Shoal was selected to assess the potential impacts and risks associated with planned discharges from the FPSO facility. The modelling location is approximately 8.1 km south-west of the indicative FPSO facility.

Modelling variability analysis

The impact assessment presented in this OPP is considered to appropriately represent all values and sensitivities that may be affected by planned discharges associated with the project. This assessment is informed by:

- the results of the baseline studies (**Section 5**) which have demonstrated that the benthic habitats and features within and surrounding the Barossa offshore development area are typical of the open offshore environment, with no significant variability in values and sensitivities
- the results of the modelling and previous impact assessment studies, as presented in **Section 6.4.8.2** to **Section 6.4.8.6**, which show that the planned discharges are expected to be diluted below levels of environmental significance within a conservative radius of approximately 21 km from the discharge location in the Barossa offshore development area.
- the point of origin for the modelling studies has been conservatively selected to be in the south-west corner of the Barossa Field, as the nearest potential location to the closest regionally significant values/sensitivities of Evans Shoal and Tassie Shoal.

Therefore, sufficient dilution of planned discharges is expected to occur within the boundary of the Barossa offshore development area (**Figure 4-2**).

The assessment concept is to define an outer area, within which impacts and risks are characterised at this early stage OPP level. Irrespective of the variability of the specific location of the FPSO facility/riser base manifold (which will be located within the Barossa Field) and modelling origin, this does not materially influence the outcomes or conclusions of environmental impact and risk associated with the planned discharges.

Discussion of the planned discharge modelling parameters and results, and a supporting impact assessment and risk evaluation, for each of the key planned discharges is provided in the following sub-sections.

6.4.8.2 Drill cuttings and fluids

Overview, modelling parameters and assumptions

To understand the distribution of the drill cuttings and fluids, ConocoPhillips commissioned RPS APASA to undertake a dispersion modelling study for an appraisal drilling campaign in the NT/RL5 permit area, which is located within the Barossa offshore development area. As the exact locations of the appraisal wells were not defined at the time of the study commencing, modelling was based on a release location at the south-west corner of NT/RL5, as it represents a conservative point to the nearest environmental values/sensitivities (i.e. Evans Shoal, Tassie Shoal and Lynedoch Bank) (APASA 2012). The location modelled is considered a conservative estimate of potential impacts and risks to these values/sensitivities as the development wells are expected to located at a similar, or greater, distance. The key inputs that informed the modelling study are also considered appropriate to represent the nature and scale of potential impacts and risks associated with any development wells.

The key modelling parameters and assumptions included:

- Continuous drilling of the well with no interval between the drilling of different well sections. This assumption provides a conservative estimate as the results will predict a higher intensity of cuttings discharge than is likely to occur during development drilling.
- The sediment grain sizes, settling velocities and distributions according to the drill fluid type and class of drill cutting were based measurements obtained during the drilling of a previous appraisal well in the Barossa Field, and therefore are considered to provide a suitable representation of the cuttings expected from the developed drilling locations for the project.
- Seabed and sea surface discharge of drilling cuttings for each well was equivalent to 341 m^3 and 143 m^3, respectively
- Seabed discharge of WBM drill fluid/residual SBM on drill cuttings for each well was equivalent to 1,642 m^3.

Modelling results

In summary, the modelling results (APASA 2012) showed:

- No contact by any drill fluids or cuttings with the closest shoals (i.e. Evans Shoal and Tassie Shoal) was predicted as a result of the discharge of drill cuttings and fluids (near-seabed and near-sea surface) at any time of the year.
- The near-seabed discharge of drill fluids and cuttings results showed larger sediments (diameter > 150 mm) settled close to the well (within approximately 60 m), with smaller sediments (< 0.15 mm diameter) deposited further from the well (up to 3 km–4 km), due to slower settling velocities, as a very thin layer of sediments. Within 100 m of the release site, the average and maximum bottom thickness was 4.5 mm and 11 mm, respectively. No sediments were predicted to make contact with Evans Shoal or Tassie Shoal at a measurable level (above a value of 0.0026 mm or 10 grams per square metre (g/m^2))[6]. The minimum distance from Evans Shoal and Tassie Shoal to the 10 g/m^2 contour was approximately 53 km and 62 km, respectively.
- The near-sea surface discharge results of drill fluids and cuttings indicated sediment material would be transported further from the release location as a result of being exposed to ocean current forces for a longer period of time. Therefore, the sediment settled over a larger area as a thinner layer. The seabed accumulation was much less compared to the near-seabed discharges, with the average and maximum bottom thickness predicted as 0.5 mm and 2.4 mm, respectively, within 100 m of the release site. No sediments were predicted to make contact with Evans Shoal or Tassie Shoal at a measurable level (i.e. 10 g/m^2). The minimum distance from Evans Shoal and Tassie Shoal to the 10 g/m^2 contour[3] was approximately 60 km and 68 km, respectively.
- Predicted deposition values of drill fluids and cuttings from the combined near-seabed and near-sea surface discharges (i.e. total accumulation) were shown to decrease with increasing distance from the well (**Figure 6-9**). Within 100 m of the discharge location, the average bottom thickness decreased to < 15 mm for the combined near-seabed and near-sea surface discharges.

Refer to **Appendix G** for the full report.

[6] The modelling applied a conservative threshold of 10 g/m^2 total (non-temporal, total load), over the entire modelling period (i.e. total period of discharge), equating to an average sedimentation rate of 0.2 g/m^2/day. The threshold is well below values reported to impact reef systems. For example, a study by Brinkman et al. 2010 for the Browse FLNG Development referral (Woodside 2013) reported that natural sedimentation rates are low at Scott Reef (< 8 g/m^2/day).

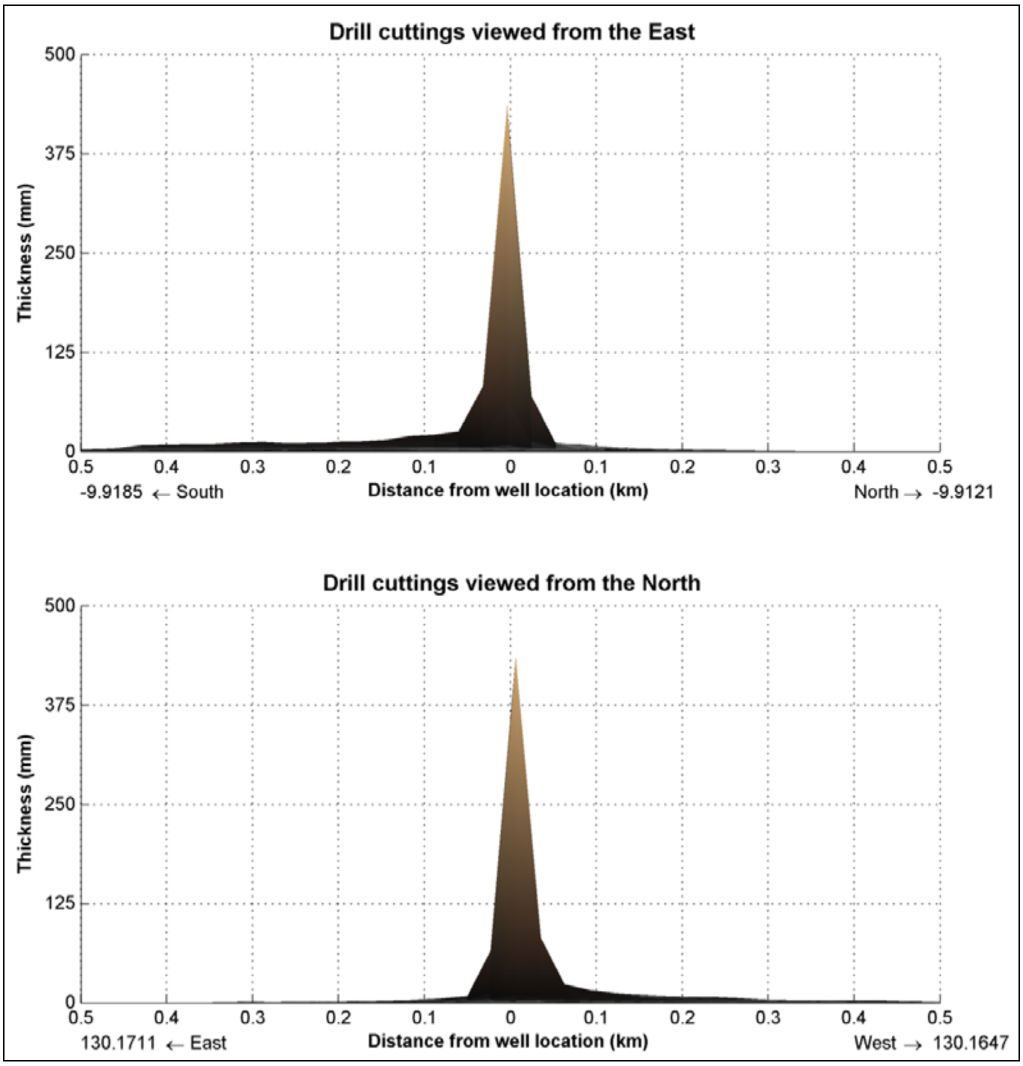


Figure 6-9: Predicted accumulation of drill cuttings and fluids discharges from seabed and sea surface discharges during development drilling

Impact assessment and risk evaluation

As outlined by the modelling results discussed above, the discharge of drill cuttings and fluids to the seabed (during riserless drilling) is expected to result in a cuttings pile developing immediately around the development well site (**Figure 6-9**). The discharge of drill cuttings and fluids near the sea surface (while drilling with a riser) will result in a sediment plume with its dispersion and settlement dependent on the current directions, prevailing wind and tidal influence. Therefore, potential impacts from the discharge of drill cuttings may include direct but localised smothering of the seabed or a localised, temporary reduction in water quality associated with increased turbidity leading to impacts to marine fauna, and displacement, smothering or toxicity of benthic habitats/communities.

No significant benthic communities within, or in the vicinity of, the Barossa offshore development area (including the Perth Treaty area) have been identified or are considered likely to be present at the depths of approximately 130 m–350 m that occur there. Information derived from previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across the area (refer **Section 5.2**) has confirmed that the seabed comprised relatively homogenous flat, soft sediments that lacked hard substrate and did not support any significant benthic habitats or communities (Jacobs 2016c). Macrofauna were recorded in low numbers and were dominated by common species of octocorals (particularly sea pens) and motile decapod crustaceans (mostly prawns and squat lobsters) (Jacobs 2016c). The infauna communities were characterised by low abundance and species diversity of burrowing taxa and demersal fish. In general, the deep water benthic characteristics were broadly consistent with those observed in the broader NMR and support widespread macrofauna and infauna species (Jacobs 2016c).

The discharge of drill cuttings and fluids is expected to result in a localised and temporary increase in turbidity levels in the water column, particularly when discharging near the sea surface. Considering the Barossa offshore development area is located in open, offshore waters any elevated suspended solids concentrations are expected to rapidly dilute with increasing distance from the development well locations as a result of the action of currents. Pelagic fauna species that may be transiting the area are unlikely to be significantly affected as they are likely to exhibit avoidance behaviour. If any contact does occur, it will be for a short duration due to the rapid dispersion of the plume within a localised area, as supported by modelling (described above), and the transient movement of pelagic marine fauna.

The potential displacement or smothering of benthic organisms is expected to be limited to the immediate vicinity of the cuttings pile with minor sediment loading anticipated to reach background levels within several kilometres (with most of the sediment deposited within several hundred metres of the release location). Impacts are expected to be confined to sediment burrowing infauna and surface epifauna invertebrates inhabiting the seabed around the well location, where cuttings deposition is greater than approximately 5 mm thickness, generally within approximately 500 m around the well location. Sediment deposition away from the immediate area of the well site will be low, equating to a thin layer of settled drill cuttings which will likely be naturally reworked into the top layers of sediment including by bioturbation (United States EPA 2000). Considering the low sensitivity and widely represented nature of the benthic communities in the Barossa offshore development area (including the Perth Treaty area), and the relatively short duration of the drill cuttings/fluids discharge, the ecological consequence of near-field burial or far-field potential impacts are expected to be minor and temporary. Recovery of affected benthic infauna, epifauna and demersal communities is also expected to occur relatively quickly, given the short-term, localised extent of the impact and natural resilience to turbid conditions.

Drilling fluids also have the potential to cause physical damage to benthic organisms through abrasion or clogging, or by changes in sediment texture that can inhibit the settlement of planktonic polychaete and mollusc larvae (Swan et al. 1994). However, these impacts are not expected to be significant given the rapid biodegradation (Bakhtyar and Gagnon 2012; Whiteway et al. 2014) and dispersion of drilling fluids and that most benthic organisms are expected to be able to recover within four months (Terrens et al. 1998). However, it is recognised that the rate of recovery of the benthic communities may vary depending on specific local conditions as other studies have noted slower rates of recovery of up to a year (Genesis 2014). A number of studies have observed that the potential impacts are localised and generally range between 50 m and 200 m from the discharge location (Oliver and Fisher 1999; Smith and May 1991; Candler et al. 1995, cited in Genesis 2014). Considering this, and the lack of significant benthic habitats/communities in the Barossa offshore development area, impacts are expected to be relatively minor.

While the Barossa offshore development area occurs within the bounds of the KEF of the shelf break and slope of the Arafura Shelf, the ecological values associated with this unique seafloor feature (i.e. patch reefs and hard substrate pinnacles) were not observed during the previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across the area (refer **Section 5.2**). Therefore, it is considered highly unlikely that the discharge of drill cuttings and fluids will significantly impact the sensitive benthic habitat values associated with this feature. The potential area of localised deposition, as shown by the modelling, will also be limited to within 100 m. Consequently, this represents a very small extent (approximately 0.03 km^2 or approximately 0.0003%) in comparison to the overall area covered by the shelf break and slope of the Arafura Shelf (approximately 10,844 km^2).

Drill fluids used in Australian drilling operations range in toxicity from non-toxic to slightly toxic, depending on the marine organisms tested (APPEA 1998). The low toxicity is attributed to the low solubility of drill fluids (e.g. barite) in the water column and low to negligible concentrations of aromatic hydrocarbons in SBM drill fluids, which are the primary source of environmental toxicity (APPEA 1998). In addition, some of the components of the drilling fluids, such as barite and bentonite, are considered to 'Pose Little or No Risk to the Environment' (OSPAR 2004).

There is little risk of direct toxicity to water-column organisms (i.e. marine mammals, marine reptiles and fish) based on the volumes of discharges, dilution, and low toxicity (Neff et al. 2000). Studies investigating the environmental impacts of WBM have observed that the toxicity to marine fauna within the water column is low (Neff et al. 2000). With regard to SBM, the risk of water column exposure to marine fauna is considered minimal as the drill fluid tends to clump together and therefore rapidly settle to the seabed (Neff et al. 2000).

A range of SBM fluids are available, which can be classified according to the chemical composition of their synthetic base fluids, for example olefins, paraffins or esters. The aquatic toxicity of various SBM base chemicals has been assessed for species of mysid shrimp, the standard organism used in toxicity tests, with the findings presented in **Table 6-33**. In assessing the ecotoxicological response to different types of SBM, the American Chemistry Council (2006) concluded that toxicity test results showed that olefin and paraffin SBM are non-toxic to the water-dwelling organisms studied. When sediment toxicity tests are considered, internal olefin and some alpha olefin products have significantly less toxicity (four to 20 times) compared to most paraffin materials.

It is recognised that the effects from SBM are not driven by single chemical constituents, and that it is more appropriate to consider effects from SBM as a combined fluid. While specific SBM fluids are not known at this early stage of the project, it is reasonable to conclude that the risk of direct toxicity of the settling SBM cuttings to water column organisms is typically low. This is supported by the conclusions of Burke and Veil (1995) that essentially all field study results indicate that because of rapid settling and dilution, drilling fluid and drill cuttings discharges do not cause significant biological effects in the water column.

In terms of the potential for drill fluids to bioaccumulate in the marine environment, the rate and extent of bioaccumulation by marine organisms is dependent on the relative affinities of the base chemical for the ambient water phase and the tissue lipid phase (Neff et al. 2000). For example, SBM fluids that contain esters as the base chemical are moderately soluble and may be bioavailable to marine fauna. However, they are readily biodegradable and therefore are unlikely to bioaccumulate to significant concentrations in tissues of marine fauna (Neff et al. 2000). Marine fauna can also readily breakdown esters within the liver and gut, converting the resulting alcohols and fatty acids to organic nutrients (Neff et al. 2000). Olefins and paraffins within SBM base chemicals are relatively large linear chains that do not permeate membranes efficiently and therefore have a low potential to bioaccumulate (Neff et al. 2000). Therefore, it is considered that the bioaccumulation of SBM base chemicals represents a very low risk to marine fauna.

Although some of the drill cuttings and fluid constituents such as barite, bentonite and some of the SBM base fluids may contain heavy metal concentrations, the metals are present primarily as insoluble mineralised salts (Kramer et al. 1980; Trefry et al. 1986; Leuterman et al. 1997; Trefry and Smith 2003, cited in Neff 2008). Solid metal sulfides have limited environmental mobility and low toxicity to plants and animals (Neff 2008). Consequently, they are not released in significant amounts to the pore water of marine sediments and therefore the risk of contamination of the sediments is very low.

Constituents such as heavy metals are likely to remain within the cuttings pile unless physical disturbance from platform activities, storms, or trawling provoke the dispersion of material and enhance the leakage of contaminants (Breuer et al. 2004, cited in Tomero et al. 2016). All of the metals in the drilling fluids also have a low bioavailability to fauna that may come into contact with them, through either the marine sediments or water column (Neff et al. 2000; Neff 2008; Trefry and Smith 2003; Crecelius et al. 2007). Therefore, the metals within the drill fluids are not considered to substantially contribute to the toxicity of the fluids (Neff et al. 2000).

In summary, based on the location of drilling within the Barossa offshore development area, volumes discharged and relatively short duration of development drilling at any one location, it is considered that the discharge of drill cutting and fluids will not result in a potential impact beyond temporary minor effects to water quality (e.g. turbidity increase) and localised burial, smothering and displacement of commonly represented benthic habitats and communities.

Table 6-33: Summary of water column aquatic toxicity data for SBM base chemicals

SBM base chemical	Species			Reference
	Mysid shrimp (species 1) 96-h LC_{50} (ppm)	Mysid shrimp (species 2) 96-h LC_{50} (ppm)	Mysid shrimp (species 3) 96-h LC_{50} (ppm)	
Internal olefins				
IO 1420	540,000 – 1,000,000			Chevron, Phillips – unpublished
IO 1518	> 1,000			Neff et al. 2000, Shell – unpublished
IO 1618	> 1,000	103,000 – 124,000		Neff et al. 2000, INEOS Oligomers – unpublished
Internal olefins	> 1,000			Neff et al. 2000
Alpha olefins				
LAO	> 1,000			Neff et al. 2000
LAO 14		120,000		Shell, INEOS Oligomers – unpublished
LAO 16		250,000		Shell, INEOS Oligomers – unpublished
LAO 1416		17,000 – 45,000		INEOS Oligomers – unpublished
LAO 1618		124,000 – 177,000		INEOS Oligomers – unpublished
Paraffins				
$C_{15\text{-}16}$ branched paraffin	> 1,000			Shrieve MSDS
$C_{10\text{-}13}$ linear paraffin	> 1,000			Shell – unpublished
Esters				
Methyl laurate			< 10,000	INPEX 2010
Isopropyl palmitate			271,701	INPEX 2010
Isopropyl oleate			52,319	INPEX 2010
$C_{4\text{-}10}$ alcohols			< 10,000	INPEX 2010
C_{16} alcohol			30,158	INPEX 2010

LC_{50} – The "lethal concentration 50%" represents the concentration at which the chemical will cause the mortality of 50% of a group of specific test species exposed to the chemical in a given time. The LC_{50} is a measure of the short-term poisoning potential of a substance.

(Source: Adapted from American Chemistry Council 2006; INPEX 2010)

6.4.8.3 Produced water

Modelling parameters and assumptions

A summary of the expected discharge volumes and key parameters for the PW assessment, are presented in **Table 6-34**.

The modelling included the following considerations and assumptions to facilitate a conservative approach:

- The assessment considered the OIW content to be 30 mg/L 24-hour average in line with former regulatory allowable concentrations stipulated in the OPGGS (E) Regulations. A general rule has also been applied in Australia and elsewhere internationally of a 24-hour average of 30 mg/L (Australian Government 2001, OSPAR 2014).
- For the purposes of this assessment, the hydrocarbon content (i.e. the OIW content) is considered to represent the most toxic component of the PW discharge stream, with the other constituents (such as mixture of hydrocarbons, dissolved inorganic salts, metals, process chemicals and mercury) present in much smaller, and therefore less toxic, concentrations. Therefore, modelling of the OIW content is considered to provide the maximum area that may be influenced by the PW plume. The other constituents that may be present in very low concentrations are not expected to change the risk or impact profile beyond the discharge plume assessed.
- The assessment criteria for evaluating potential impacts to the environment from hydrocarbons was a dilution level of 1:4,285 (or < 7 µg/L OIW concentration), as this represents a 99% species protection low reliability trigger level based on ANZECC & ARMCANZ (2000) guidelines. This dilution level is considered highly conservative as ecotoxicity testing of the Barossa reservoir fluid (herein referred to as Barossa condensate) determined that the 99% species protection threshold for unweathered Barossa condensate was 456 µg/L (Jacobs 2017), which equates to a dilution level of approximately 1:65 (**Section 6.4.10.4**).
- The assessment criteria for evaluating potential impacts to the marine environment from increased water temperature was a 3°C exceedance above ambient, in line with International Finance Corporation (IFC) guidelines for cooling water. This criterion was conservatively applied to the PW discharge stream.

Table 6-34: Summary of PW modelling parameters

Parameter	Value
Flow rate	Minimum flow rate: Approximately 1,590 m^3/day Maximum flow rate: Approximately 3,260 m^3/day
Outlet pipe internal diameter	0.31 m
Depth of pipe below sea surface	10 m
Discharge salinity	15 ppt
Discharge water temperature	60°C
Discharge OIW (i.e. hydrocarbon) concentration	30 mg/L

Modelling results

In summary, the modelling results, which took into account the higher flow rates expected towards the end of field life (RPS 2017a), showed:

- Overall, the area influenced by PW discharges from the proposed FPSO facility was relatively localised during all seasons.
- Contact with shoals/banks, reefs and islands, AMPs or KEFs was not predicted during any season.
- The PW plume was predicted to extend downward to approximately 1 m below the outlet pipe (i.e. to 11 m below the sea surface), depending on the discharge flow rate and current strengths.
- The temperature of the PW plume reduced to within 3°C of ambient water temperature within 2 m horizontally of the release location. **Figure 6-10** shows the temperature of the PW plume during minimum flow rates in transitional conditions (where the temperature decline was the slowest) under varying current speeds.
- The level of dilution was directly attributable to the speed of the current. Weaker currents had minimal effect on the plume during the rise process, meaning it reached the surface quicker and thus, slowed the rate of dilution. Strong currents were able to push the buoyant plume up to a maximum horizontal distance of approximately 36.3 m and 26.3 m for the minimum and maximum flow rate, respectively, allowing for additional mixing prior to reaching the sea surface.
- Upon encountering the sea surface, the diameter of the PW plume at the sea surface ranged from approximately 2.9 m to 10.6 m during weak and strong currents respectively.
- Dilution levels of 1:50, 1:75 and 1:100 were predicted at a maximum distance of approximately 20 m, 40 m and 70 m from the discharge location for the anticipated minimum and maximum discharge flow rates for all seasons.
- A dilution level of 1:4,285 (or < 7 µg/L OIW concentration) was predicted at a maximum distance of approximately 4.6 km and 6.1 km from the discharge location for the anticipated minimum and maximum discharge flow rates, respectively, for all seasons (**Figure 6-11**). Considering the maximum distance of the 1:4,285 dilution contour and the location of the closest shoals/banks, no toxic impacts associated with residual OIW concentration are expected to non-transitory environmental values/sensitivities.
- Based on a 1:4,285 dilution contour, the PW discharge was predicted to cover approximately 4.3 km^2 and 12.4 km^2 for all seasons for minimum and maximum discharge flow rates, respectively.

Refer to **Appendix H** for the full modelling report.

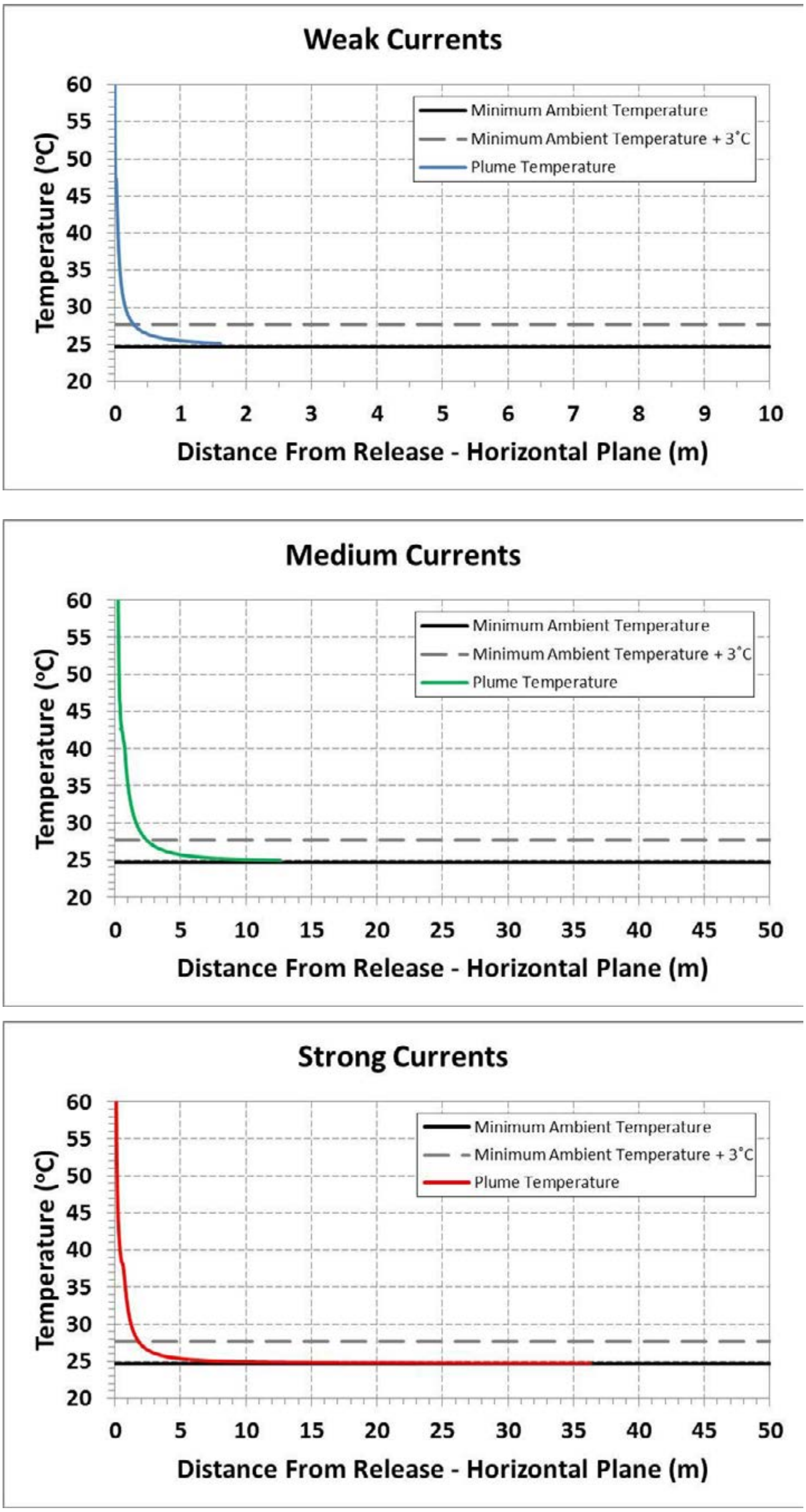
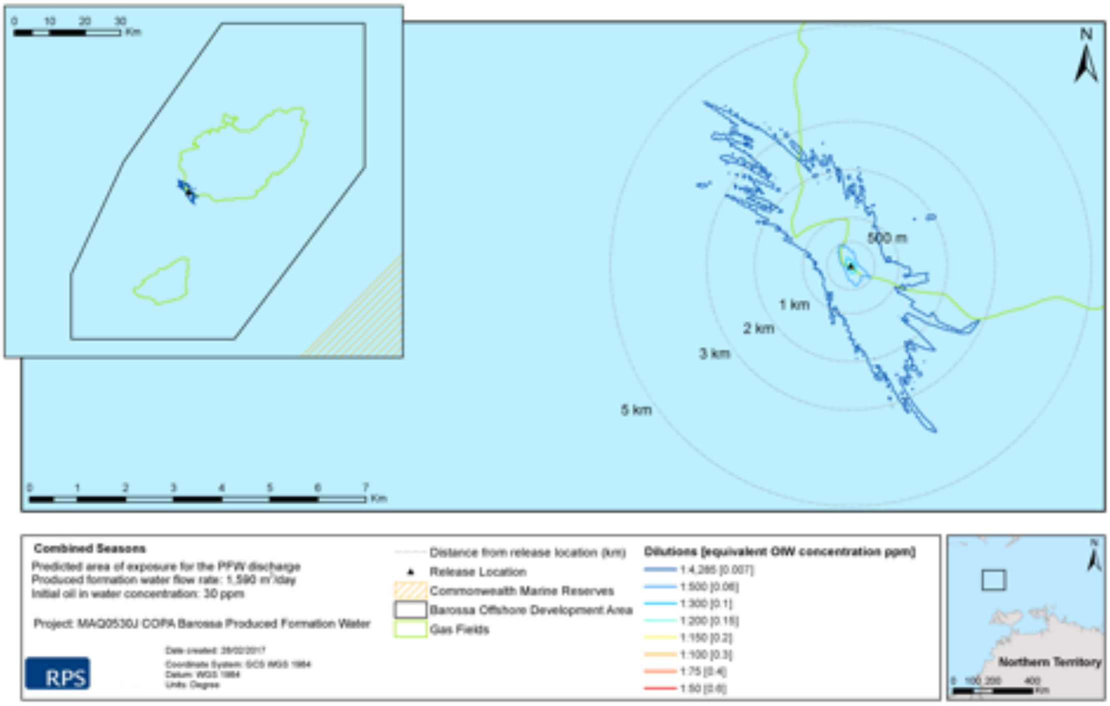
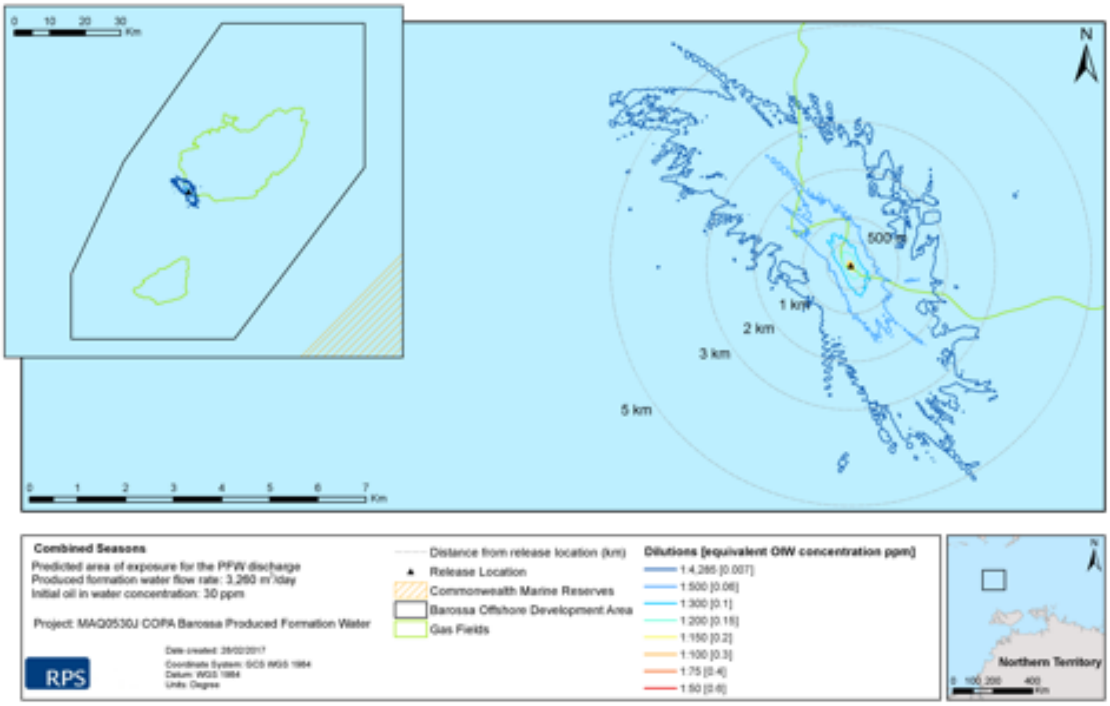


Figure 6-10: Predicted PW plume temperature



a) Minimum discharge rate (1,590 m^3/day)



b) Maximum discharge rate (3,260 m^3/day)

Figure 6-11: Predicted extent of the PW oil-in-water dilutions

Impact assessment and risk evaluation

As shown by the modelling results, the discharge of PW is expected to result in a localised and temporary increase in water temperature (within approximately 2 m horizontally of the release location) and decline in water quality associated with the constituents within the PW plume (e.g. mixture of hydrocarbons, dissolved inorganic salts, metals and process chemicals) in the upper water column (within approximately 11 m below the sea surface).

The PW discharge is expected to be low salinity (15 ppt) and warmer than receiving waters (60°C) and will therefore rise to the surface. Mixing and dilution will be facilitated by the release point being below the surface. Further mixing and dilutions will occur due to surface currents, winds and wave action.

The risks from PW generally diminish significantly within short distances from the discharge due to rapid dilution. The modelling results for the project reported initial near-field average dilutions of 89–190 fold being achieved within < 10 m of the discharge with average dilutions of 318–1,224 fold achieved within 10 m–37 m of the discharge location, depending on the season (RPS 2017a). The discharge diluted to a 99% species protection threshold (1:4,285 or < 7 µg/L OIW concentration) at a maximum distance of approximately 4.6 km and 6.1 km from the discharge location. As outlined above, this dilution level is considered to be highly conservative considering the 99% species protection threshold for unweathered Barossa condensate was determined to be 456 µg/L (1:65 dilution) (Jacobs 2017). Considering this, potential toxicological impacts are not predicted to be observed more than tens of metres beyond the discharge point. For comparison, assessment of PW from the Sunrise Gas Project (approximately 210 km west of the Barossa offshore development area) concluded that impacts associated with chemical toxicity from the PW stream would not be experienced further than a radial distance of 15 m and at a depth of 3.3 m below the point of PW discharge (Office of Environment and Heritage 2003).

The potential impacts and risks associated with the discharge of PW are determined by the fate of the constituents released to the marine environment. Residual amounts of dissolved hydrocarbon compounds that remain in the PW stream following treatment may include benzene, toluene and xylenes (BTEX), PAHs and phenols. BTEX are generally the most abundant hydrocarbons in PW, however they are also highly volatile and are therefore lost rapidly during treatment of PW and mixing with the receiving waters (International Association of Oil and Gas Producers (IOGP) 2005; Neff et al. 2011; Ekins et al. 2007). BTEX also biodegrades rapidly in the marine environment and is not known to accumulate to significant concentrations within marine organisms (IOGP 2005). BTEX are toxic to marine fauna as they have potential to alter the permeability of cell membranes, particularly in the gills of fish, and can cause developmental defects in marine biota fauna (Fucik et al. 1994; National Research Council 2003). However, given the rapid loss of BTEX components, exposure to marine fauna is extremely low (IOGP 2005).

PAHs are less volatile than BTEX, relatively insoluble and can accumulate in the marine environment (IOGP 2005; Ekins et al. 2005). PAHs can be broadly divided into two types; those of low molecular weight and those of high molecular weight. PAHs dissolved in PW are predominantly low molecular weight and, while moderately toxic, they are not mutagenic nor carcinogenic (Neff 2002; IOGP 2005). Higher molecular weight PAHs are rarely detected in treated PW as, due to their low aqueous solubility, they are associated primarily with dispersed oil droplets which are removed during treatment by the PW treatment system (Neff et al. 2011). Higher molecular PAHs are also unlikely to be present in the PW discharged in the Barossa offshore development area, as the majority of the PAHs within the Barossa condensate are the lower molecular PAHs (one ring and two ring aromatics) (RPS 2017e). PAHs are generally removed from the water column through volatilisation to the atmosphere upon reaching the sea surface, particularly the lower molecular weight fractions (Schmeichel 2017). PAHs can also degrade in the water column with half-lives ranging from less than a day to several months, with the more abundant and lower molecular weight compounds being more degradable (OGP 2002, cited in Ekins et al. 2005).

As outlined above, PAHs are toxic to marine fauna as they can affect reproductive and biological functions. In addition, higher molecular weight PAHs can be also be carcinogenic (Schmeichel 2017). Lower molecular weight PAHs are less toxic as their ability to accumulate in the tissue of marine fauna is lower when compared to higher molecular weight PAHs (IOGP 2005). However, higher molecular PAHs generally have low availability to marine organisms as they tend to remain associated with oil droplets and sorb tightly to particulates; though, this allows them to remain in marine sediments for months to years where they can affect benthic fauna (Schmeichel 2017). In well-mixed offshore waters, such as those in the Barossa offshore development area, elevated concentrations of higher molecular PAHs in sediments have been observed to be limited to within several hundred metres from a high-volume PW discharge location (Neff et al. 2011). Given this, and that the Barossa condensate comprises a small percentage of higher molecular weight PAHs, the potential for environmental impact associated with accumulation of PAHs in sediments is considered to be very low. Phenols may also be dissolved in the PW stream; however, they are highly volatile and rapidly biodegraded by micro-organisms in seawater, and therefore pose a low risk to marine fauna (IOGP 2005). In summary, given the reservoir characteristics of Barossa condensate exhibiting predominantly low molecular weight PAHs, and their lower toxicity relative to higher molecular weight PAHs, and the low residual concentrations expected to be released, the risk of significant impact is low.

The various trace metals that may be present in low concentrations in the PW stream are generally in a low oxidative state and on release to the marine environment rapidly oxidise and precipitate into solid forms. Marine fauna have the ability to regulate the availability of many trace metals, with few trace metals shown to accumulate significantly (IOGP 2005). While concentrations of trace metals in PW can be significantly greater than those in the marine environment, they are rapidly reduced through dilution and mixing processes, and other physicochemical reactions to levels that pose a low risk to the receiving environment (IOGP 2005).

Mercury is a key metal of concern and may occur in low concentrations in the PW discharged. Mercury is expected to be mainly in the form of liquid elemental mercury, with production of some mercury sulphide likely. Liquid elemental mercury is relatively unreactive and insoluble in water (Neff 2002; Boszke et al. 2002). Of the different forms of mercury, methyl-mercury is of greatest concern as it is readily bioavailable, has potential to bioaccumulate and can cause toxicological effects at very low doses. While methyl-mercury is not expected to be present in the reservoir(s), as the presence of this form of mercury in natural gas and natural gas liquids (which includes condensate) is uncommon (Row and Humphrys 2011; Carnell and Row 2014), it has been conservatively assumed for the purposes of this assessment that trace amounts may be present within the PW stream. Methylation of elemental mercury can also occur in the marine environment by microorganisms (Risher 2003). However, the formation of methyl-mercury mainly occurs in anaerobic conditions and is enhanced in low pH (i.e. acidic) waters (Risher 2003; Boszke et al. 2002); which are not characteristic of the conditions in the Barossa offshore development area (Section 5.4.4). Considering this, and based on the conservative assumption that methyl-mercury is present within the reservoir (which is highly unlikely), it is possible that there may be a slight accumulation of mercury in marine sediments within the vicinity of the PW discharge (within hundreds of metres). When taking into account the low sensitivity and widely represented nature of the benthic communities in the Barossa offshore development area, the ecological risk of slight increases of mercury in the sediments is expected to be low.

Trace levels of process chemicals may be present in the PW. Some of the process chemicals will be in concentrations below that which are toxic to marine fauna, such as scale inhibitors, while others may be at concentrations that have potential to cause impact or contribute to the aquatic toxicity of the PW, such as corrosion inhibitors and biocides (Neff 2002). The ecotoxicological impacts of process chemicals in PW discharges was investigated in a study by Henderson et al. (1999). The study tested 11 commonly used process chemicals (including biocides, corrosion inhibitors and demulsifiers) for their acute toxicity to marine bacterium, both directly in aqueous preparations and following their partitioning between oil and water phases. The chemicals selected represented a range of toxicities as per the OCNS ranking system. With regard to the relevance of the oil and water phases, the toxic components of the process chemicals have different affinities to these phases. For example, the toxic components of biocides partition into the water phase of the PW discharge, corrosion inhibitors partition primarily into the water phase while demulsifiers partition into the oil phase (Schmeichel 2017).

The Henderson et al. (1999) study observed that for the majority of the process chemicals tested, the toxicity of the water phase to the test organism following partitioning against the oil phase, was not significantly altered by the presence of process chemicals when used in their normal operational dosage concentrations. However, the study also stated that, should the chemicals be used in high concentrations, they may increase the toxicity of the PW as higher concentrations could increase the partitioning of the oil phase components into the water phase (Henderson et al. 1999). A toxicological review of this study by Schmeichel (2017) notes that the study concluded that process chemicals make a small contribution to the overall acute toxicity profile of PW discharges and even chemicals which are classified as highly toxic, may not actually present an acute toxicity risk at dosages representing normal operating conditions. Considering the observations by Henderson et al. (1999) and Schmeichel (2017), and that concentrations of the process chemicals used for the Barossa project will align with normal operational dosages, it is considered that ecological risk associated with trace levels of process chemicals in the PW discharge stream will be low.

The accumulation of PW chemical constituents in the water column and benthic sediments is influenced by the volume/concentration in PW discharges and subsequent rate of dilution, the ability of the constituents to be taken up by sediments, the area of the seabed that is contacted and re-suspension, bioturbation and microbial decay in the water column and on the seabed. Results from monitoring programs have generally shown that natural dispersion processes control the concentrations of toxic metals in the water column and sediments slightly above natural background concentrations (Neff et al. 2011).

Considering the Barossa offshore development area (including the Perth Treaty area) is located in open, offshore waters, which are subject to large-scale currents and mixing from the influence of the ITF, the elevated water temperatures and concentrations of the constituents within the PW plume are expected to rapidly dilute and reach levels below those which may cause harm to marine species, as demonstrated by the modelling outcomes. A PW plume such as that expected within the Barossa offshore development area will be very well mixed and have little interaction with the seabed and sediments in any elevated concentrations. Consequently, impacts are expected to be relatively localised (i.e. limited to deep offshore waters), with the PW plume not expected to impact non-transitory environmental values/sensitivities, such as the surrounding shoals and banks. This is supported by the modelling results, as discussed above.

The PW discharge is not expected to contact the KEF of the shelf break and slope of the Arafura shelf as the values associated with the KEF, a unique seafloor feature comprising patch reefs and hard substrate pinnacles, were not observed to occur in the Barossa offshore development area during the previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across the area (refer **Section 5.2**). Considering this, and that the PW discharge plume only extends 11 m below the water surface (i.e. approximately a vertical separation of > 119 m above the seabed), the risk of the plume contacting the sensitive benthic habitat values associated with the KEF is highly unlikely.

Large numbers of pelagic marine fauna species are unlikely to be impacted as the Barossa offshore development area does not contain any significant feeding, breeding or aggregation areas for marine fauna. Therefore, marine fauna within the area are likely to be relatively limited in number, transient and well represented throughout the region. If contact with the plume does occur with any marine fauna, it will be for a short duration due to the rapid dispersion of the plume and the transient movement of marine fauna, such that exposure time may not be of sufficient duration to cause a toxic effect.

As outlined in **Section 5.7.12**, engagement with the commercial fishermen operating in the Timor Reef Fishery determined that the Barossa offshore development area is not intensively fished. Recent fishing effort has increased to the south-west area of the fishery, which is at least 50 km from the Barossa offshore development area. Considering this, and the nature of the PW discharge plume as described above, potential impacts to the commercial fishery are unlikely.

The potential for impact associated with the bioaccumulation of PW constituents in benthic sediments is considered low and limited to a potential localised effect on a limited number of benthic fauna species immediately surrounding the FPSO facility.

During operations, verification monitoring of hydrocarbon concentrations of the PW discharge stream will be undertaken prior to discharge. The results will be reviewed to confirm compliance with the management controls presented in this OPP and in the relevant activity-specific EP. Refer to **Section 7.2.3** for further detail on the environmental monitoring that will be undertaken throughout the life of the project. ConocoPhillips will also adopt an adaptive management framework (**Section 7.3**) to actively manage PW discharges throughout the life of the project.

6.4.8.4 Cooling water

Modelling parameters and assumptions

A summary of the expected discharge volumes and key parameters for the cooling water assessment are presented in **Table 6-35**.

The modelling included the following considerations and assumptions to facilitate a conservative approach:

- The assessment criteria for evaluating potential impacts to the environment from chlorine were:
  - a dilution level of 1:231 (or 13 ppb chlorine concentration), as this represents the predicted no effect concentration for acute exposure at the 99% species protection level based on Chariton and Stauber (2008)
  - a dilution level of 1:1,500 (or 2 ppb chlorine concentration), as this represents the predicted no effect concentration for chronic exposure at the 99% species protection level based on Chariton and Stauber (2008).
- The assessment criteria for evaluating potential impacts to the marine environment from increased water temperature was a 3°C exceedance above ambient within 100 m of the release locations, in line with IFC guidelines.

Table 6-35: Summary of cooling water modelling parameters

Parameter	Value
Flow rate	Minimum flow rate: 288,000 m^3/day Maximum flow rate: 360,576 m^3/day
Outlet pipe internal diameter	1 m
Depth of pipe below sea surface	10 m
Discharge salinity	33.6–34.1 practical salinity units/ppt (variation based on ambient mean seasonal considerations)
Discharge water temperature	45°C
Residual chlorine concentration	3 ppm (3,000 ppb)

Modelling results

In summary, the modelling results (RPS 2017b) showed:

- Overall, the area influenced by cooling water discharges from the FPSO facility was relatively localised during all seasons.
- Contact with shoals/banks, reefs and islands, AMPs or KEFs was not predicted during any season.
- The cooling water discharge was predicted to initially extend downward, due to the momentum of the plume, creating a turbulent mixing zone ranging between approximately 40 m and 70 m below the sea surface (maximum flow rate). The cooling water extended deeper into the water column under weak current conditions. However, the plume was still a significant distance above the seabed (approximately > 60 m).
- Upon encountering the sea surface, the diameter of the cooling water plume at the sea surface ranged from approximately 17.6 m to 43.0 m (maximum flow rate) during weak and strong currents, respectively.
- The level of dilution was directly attributable to the speed of the current. Weaker currents had minimal effect on the plume during the rise process, meaning it reached the surface quicker and thus slowed the dilution rate.
- The temperature of the cooling water plume returned to within 3°C of ambient water temperature within approximately 12 m of the discharge location for all discharge scenarios and seasons. **Figure 6-12** shows the temperature of the cooling water plume during maximum flow rates in transitional conditions (where the temperature decline was the slowest) under varying current speeds.
- A dilution level of 1:231 (or 13 ppb chlorine concentration) was predicted at a maximum distance of approximately 3.6 km and 4.6 km from the discharge location for the anticipated minimum and maximum discharge flow rates, respectively, for all seasons.
- A dilution level of 1:1,500 (or 2 ppb chlorine concentration) was predicted at a maximum distance of approximately 19.3 km and 20.5 km from the discharge location for the anticipated minimum and maximum discharge flow rates, respectively, for all seasons.
- Considering the maximum distance of the 1:231 and 1:1,500 dilution contours and the location of the closest shoals/banks, no toxic impacts associated with residual chlorine concentration are expected to non-transitory environmental values/sensitivities.
- Based on the 1:231 dilution contours, the cooling water discharge was predicted to cover approximately 22.3 km^2 and 34.0 km^2 for all seasons for minimum and maximum discharge flow rates, respectively (**Figure 6-13**).
- Based on the 1:1,500 dilution contours, the cooling water discharge was predicted to cover approximately 376.2 km^2 and 420.2 km^2 for all seasons for minimum and maximum discharge flow rates, respectively (**Figure 6-13**).

Refer to **Appendix I** for the full modelling report.

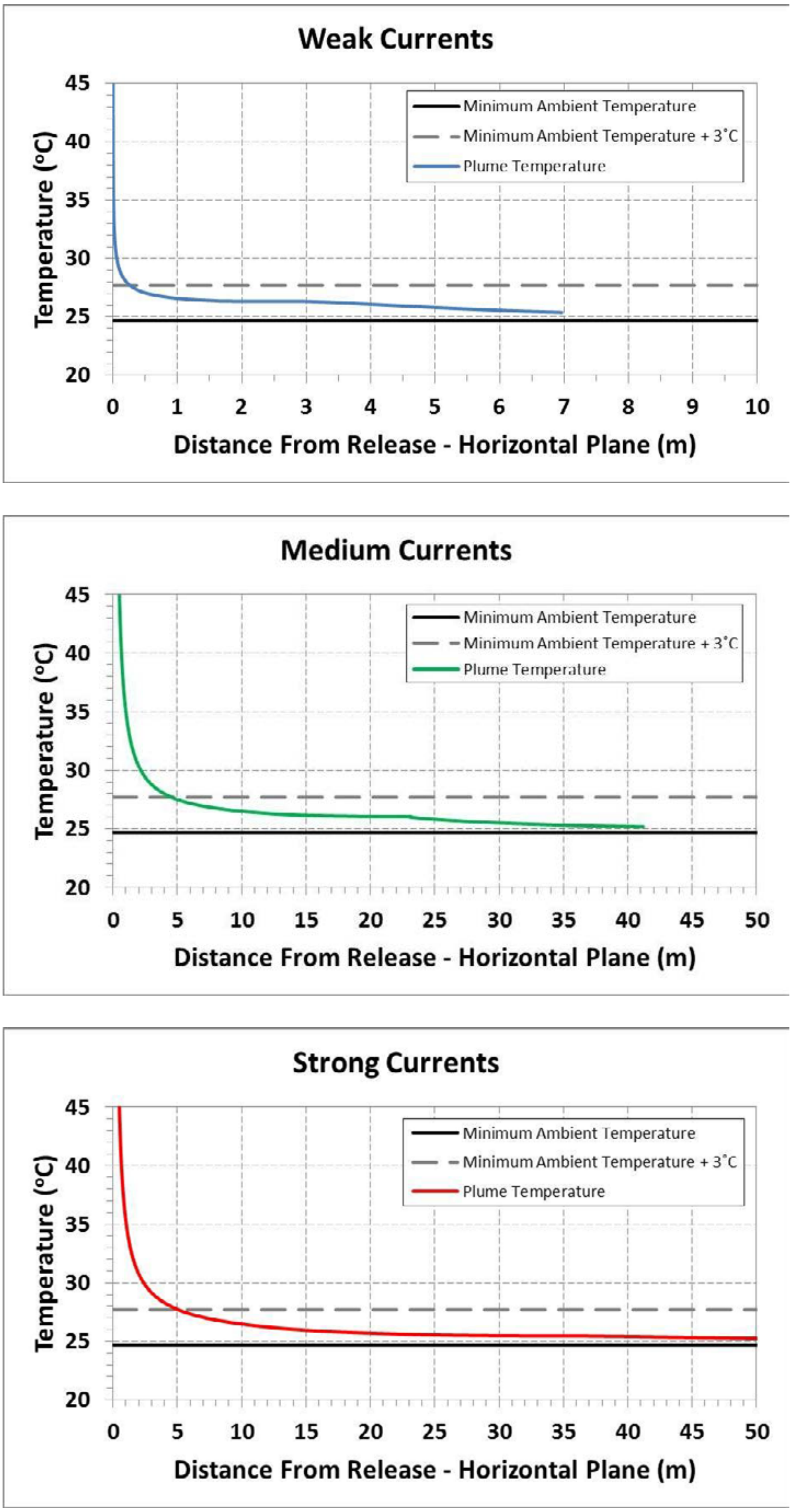
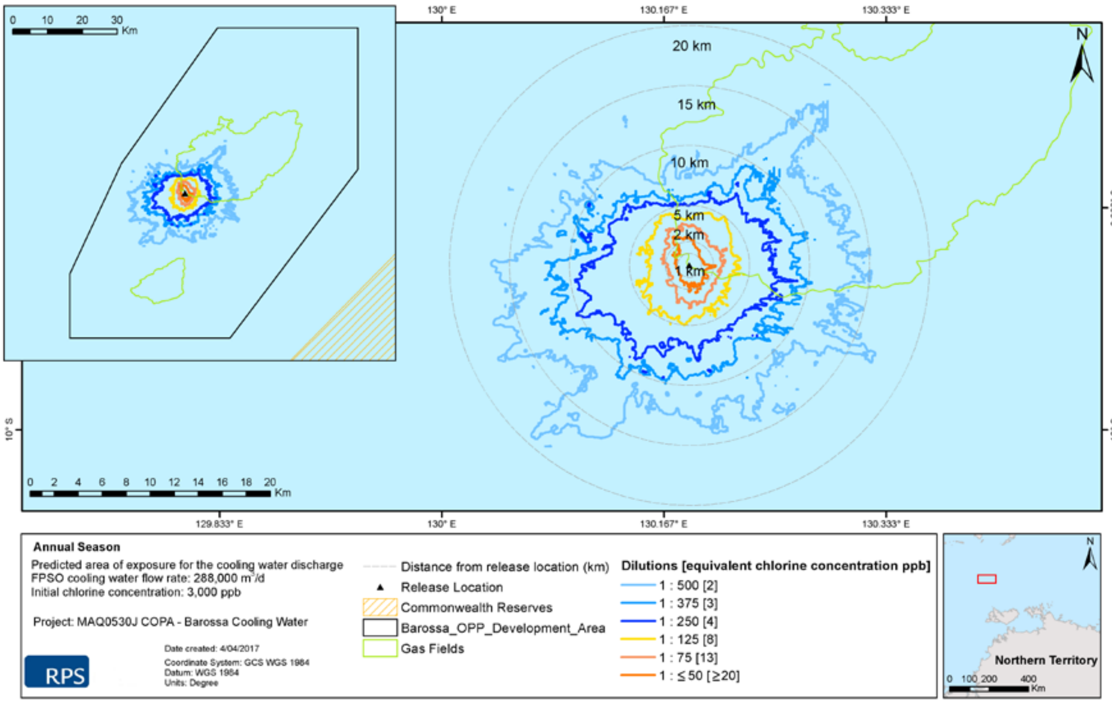
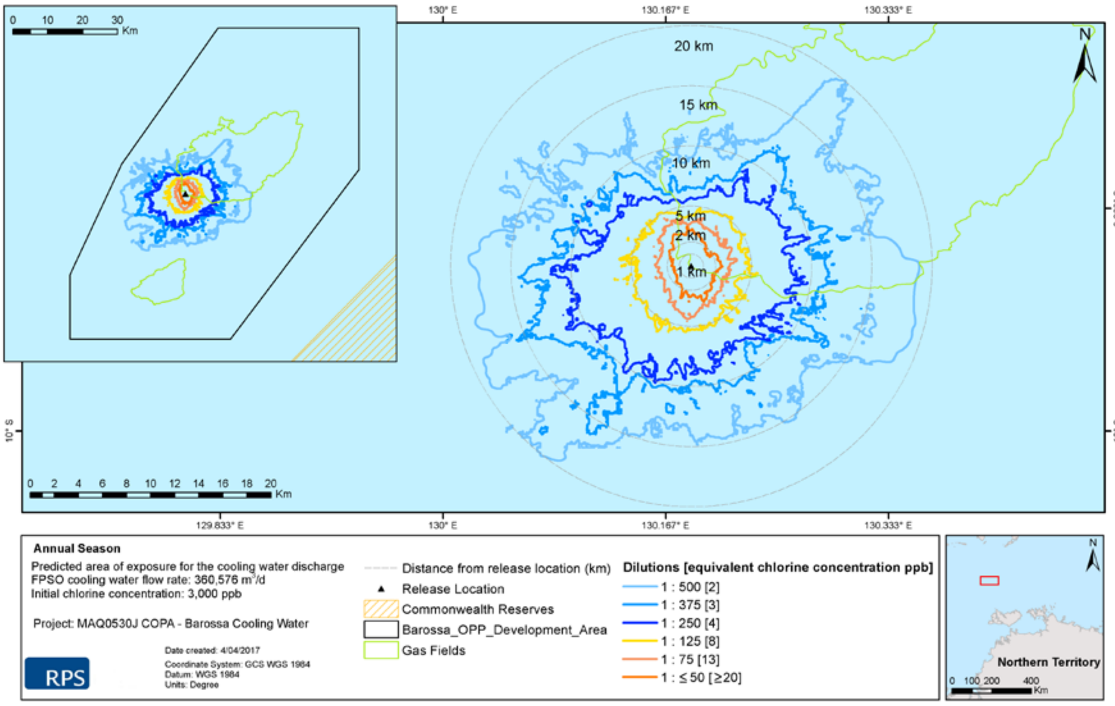


Figure 6-12: Predicted cooling water plume temperature



a) Minimum discharge rate (288,000 m^3/day)



b) Maximum discharge rate (360,576 m^3/day)

Figure 6-13: Predicted extent of residual chlorine in the cooling water plume

Impact assessment and risk evaluation

The discharge of cooling water is expected to result in a localised and temporary increase in water temperature and chlorine in the upper to mid water column (< 70 m below the sea surface).

Elevated seawater temperatures have been observed to cause alteration of the physiological processes (particularly enzyme-mediated processes) in marine biota (Wolanski 1994) and can result in a range of effects, such as behavioural responses (including attraction or avoidance behaviour), minor stress and potential mortality from prolonged exposure. However, as the temperature of the cooling water plume is predicted to return to within 3°C of ambient water temperature within approximately 12 m of the cooling water discharge location the area influenced by elevated water temperatures is limited and the potential for any behavioural responses is expected to be extremely minor. Furthermore, prolonged exposure is highly unlikely as the underwater noise monitoring survey (JASCO 2016a) has shown that marine fauna individuals transit through the Barossa offshore development area, rather than spending time feeding, breeding or aggregating in the local marine environment.

The majority of the chlorine injected into the cooling water system will react and be neutralised by the system, with discharged concentrations in the order of 3 ppm. Chlorine is a strong oxidant and following discharge, the residual chlorine-produced oxidants (hypochlorous acid, hypochlorite ions and hypobromous acid) react rapidly with inorganic constituents (e.g. sodium, iron (II), nitrite and sulphide to produce non-harmful chlorides, such as sodium chloride (salt)). Therefore, the decay of the chlorine-produced oxidants released to the marine environment is rapid.

A study by Taylor (2006) investigating the effects of chlorination (from biofouling agents used in seawater cooling units) on coastal and estuarine environments suggested very limited impact of oxidant use and the associated chlorination by-products on receiving waters, both in terms of plume toxicity or any more widespread ecotoxicological influence.

As discussed in **Section 6.4.8.4**, given the location of the Barossa offshore development area (including the Perth Treaty area) in a high-mixing marine environment, impacts are expected to be relatively localised (i.e. limited to deep offshore waters), with cooling water discharges unlikely to impact non-transitory environmental values/sensitivities, such as the surrounding shoals and banks. This is supported by the modelling results, as discussed above. In summary, any potential for acute toxicity[1], chronic toxicity[2] and thermal impacts to marine biota would be expected to be limited to within approximately 4.6 km, 20.5 km and 12 m from the discharge location, respectively.

The cooling water discharge is not expected to contact the KEF of the shelf break and slope of the Arafura shelf, as the seabed features associated with the KEF, a unique seafloor feature comprising patch reefs and hard substrate pinnacles, were not observed to occur in the Barossa offshore development area during the previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across the area (refer **Section 5.2**). Given this, and that the cooling water discharge plume extends 40 m–70 m below the water surface (i.e. a vertical separation of approximately > 60 m above the seabed), the risk of the plume contacting the benthic habitat values associated with the KEF is highly unlikely.

Relatively few individuals of pelagic fauna, including marine mammals, marine reptiles, fish, sharks and rays, are expected to inhabit the Barossa offshore development area as it does not contain any significant feeding, breeding or aggregation areas for marine fauna. Therefore, marine fauna within the area are likely to be transient and well represented throughout the region. If contact does occur with any marine fauna it will be for a short duration due to the rapid dispersion of the plume and the transient movement of marine fauna, such that exposure time may not be of sufficient duration to cause a toxic effect.

The cooling water discharge is not expected to affect commercial fishermen operating in the Timor Reef Fishery. Engagement with the commercial fishermen determined that the Barossa offshore development area is not intensively fished, with recent fishing effort focused in the south-west area of the fishery at least 50 km from the Barossa offshore development area (**Section 5.7.12**). Considering this, and the nature of the cooling water discharge plume as described above, potential impacts to the Timor Reef Fishery are unlikely.

[1] The predicted no effect concentration in the event of acute exposure (i.e. a single exposure lasting less than one day) to chlorine at the 99% species protection level.

[2] The predicted no effect concentration in the event of acute exposure (i.e. a single exposure lasting less than one day) to chlorine at the 99% species protection level.

6.4.8.5 Wastewater modelling parameters

A summary of the expected discharge volumes and key parameters for the assessment of wastewater (sewage, greywater, bilge and deck drainage) are presented in **Table 6-36**.

Table 6-36: Summary of wastewater modelling parameters

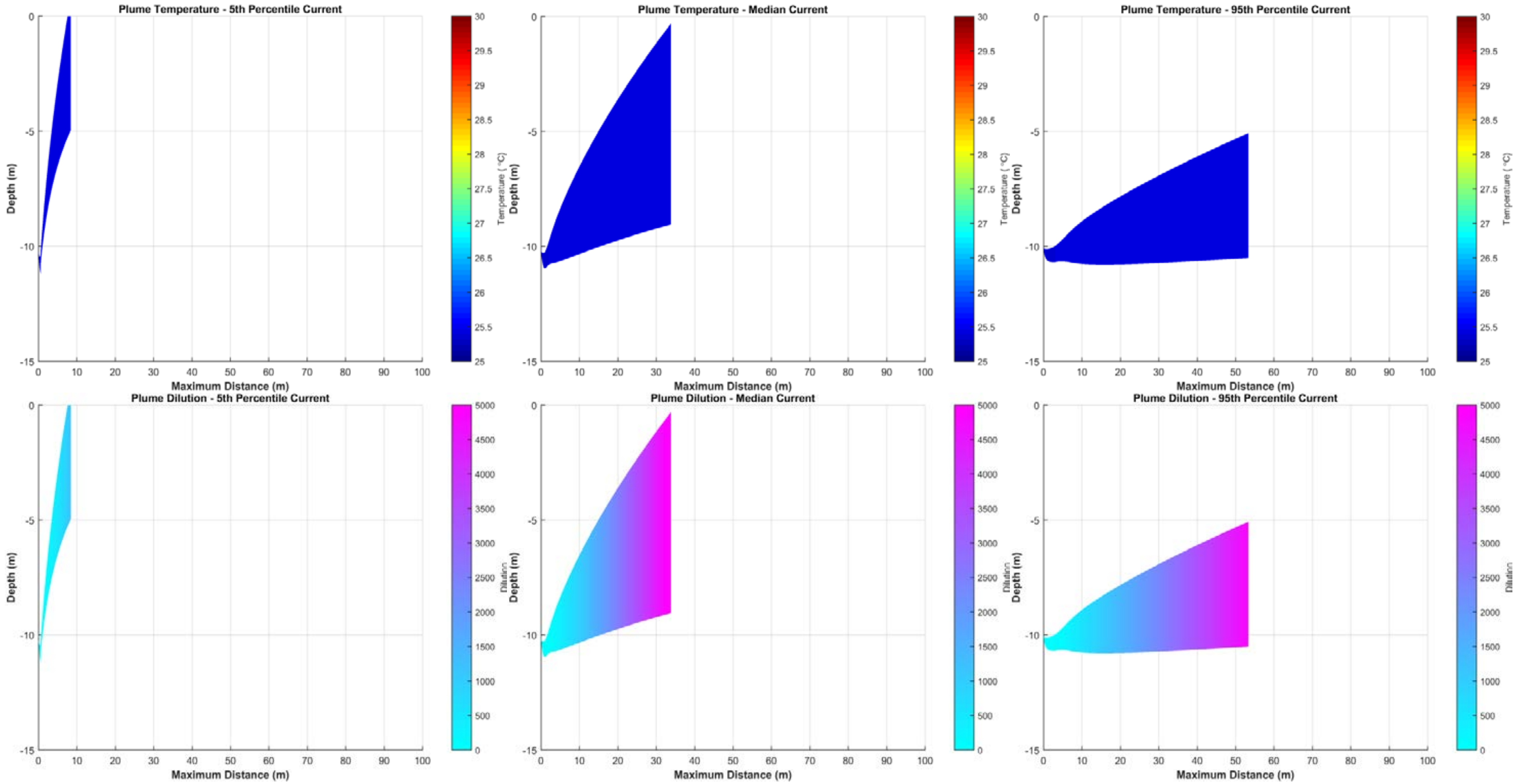
Parameter	Value
Flow rate	Commissioning flow rate: 96.1 m^3/day Operational flow rate: 45 m^3/day
Outlet pipe internal diameter	0.03 m
Depth of pipe below sea surface	10 m
Discharge salinity	1 ppt
Discharge water temperature	25°C
Discharge OIW (i.e. hydrocarbon) concentration	30 mg/L
Discharge total suspended solids concentration	50 mg/L
Discharge coliform bacteria	250 col/100 mL

Modelling results

In summary, the modelling results (RPS 2017c) showed:

- Overall, the area influenced by wastewater discharges was relatively localised during all seasons.
- Contact with shoals/banks, reefs and islands, AMPs or KEFs was not predicted during any season.
- The wastewater plume was predicted to initially extend downward, due to the momentum of the plume, to approximately < 1 m below the outlet pipe (i.e. to < 11 m below the sea surface) under all current conditions.
- There were no observable differences between the final plume temperature and ambient water temperature under all discharge flow rates (i.e. commissioning and operations) and all current speeds.
- The wastewater discharge stream would mix to very low levels (1:5,000 dilution with regard to oil/grease, total suspended solids and coliform bacteria) within a maximum distance of approximately 53.3 m from the discharge location (based on the higher flow rates expected during commissioning and strong currents), as a result of a combination of low discharge volumes, buoyancy of the stream and high near-field dispersion rates.
- A minimum dilution of 1:10 was achieved for both commissioning and operations wastewater discharges within a maximum of < 0.4 m from the discharge location based on all seasons modelled.
- A 1:100 dilution was achieved for both commissioning and operations wastewater discharges within a maximum of < 3.6 m from the discharge location based on all seasons modelled.
- The level of dilution was directly attributable to the speed of the current. Weak currents had limited influence on the discharge plume as it rose through the upper water column; therefore, the plume rose faster and thus slowed the rate of dilution. Medium and strong currents were able to push the buoyant plume horizontally, therefore allowing for greater dilution of the discharge plume. **Figure 6-14** shows the temperature and dilution results for the commissioning phase discharge flow for the summer months (where the temperature decline was the slowest and the dilution distance the longest) under varying surface currents.

Refer to **Appendix J** for the full modelling report.



Note the differing scales for the x- and y-axis.

Figure 6-14: Commissioning phase discharge temperature and dilution results for wastewater

Impact assessment and risk evaluation

Considering the relatively low discharge rates, predicted plume characteristics and location of the Barossa offshore development area in open, offshore waters (which are subject to large-scale currents and high dilution forces), no significant impacts to the marine environment are expected from the planned discharge of wastewater. Any potential impacts are also expected to be highly localised and temporary and will not affect non-transitory environmental values/sensitivities, such as the surrounding shoals and banks, and unique seabed KEFs. This is supported by the modelling results, as discussed above.

As the Barossa offshore development area does not contain any significant feeding, breeding or aggregation areas, any marine fauna within the area are likely to be relatively limited in number, transient and well represented throughout the region. If contact does occur with any marine fauna, it will be for a short duration due to the rapid dispersion of the plume and the transient movement of marine fauna, such that exposure time is highly unlikely to be of a duration that will cause significant adverse effect.

As outlined in **Section 4.3.1**, should the concept to develop the Caldita Field include a WHP, small volumes of wastewater may be discharged from the WHP when personnel are present to undertake infrequent routine operational maintenance activities. As typical manning during maintenance would be less than 10 persons for a single shift, any wastewater discharge will be significantly smaller than the operational flow rate of the FPSO facility assessed above and therefore, any discharges will be localised (i.e. affect the waters in the immediate vicinity of the discharge location within the Barossa offshore development area) and temporary (i.e. in the order of several days).

6.4.8.6 Dewatering of flooding fluid

Modelling parameters and assumptions

A summary of the expected discharge volumes and key parameters for the dewatering discharge assessment from the gas export pipeline, at the FPSO facility riser base manifold located within the Barossa offshore development area, are presented in **Table 6-37**.

The modelling included the following considerations and assumptions to facilitate a conservative approach:

- As the type of biocide to be used for the project is yet to be selected, three biocides were modelled; Gluteraldehyde, Tetrakis (hydroxymethyl) phosphonium sulfate (THPS) and Hydrosure 0-3670R.
- For the purposes of this assessment, biocide is considered to be the primary chemical constituent of interest within the dewatering discharge as it is identified as having the highest toxicity to marine receptors. Therefore, modelling of the biocide concentration is considered to provide the maximum area that may be influenced by the dewatering discharge.
- The residual discharge concentration of the biocide was assumed to be the same as the initial dosing concentration. This represents a conservative approach as it does not account for the expected degradation/decay of the active ingredients during residence time in the pipeline.
- The assessment criterion for evaluating potential impacts to the environment from biocide was 1ppm (equivalent to 1 mg/L). This threshold concentration/trigger value was informed by a review of published literature (Chevron 2015, 2014a; Sano et al. 2004; Tjandraatmadja 2005; European Chemicals Agency 2017; Hugdins 1991, cited in NT Government 2003) and is considered to represent a conservative presented LC_{50} value (i.e. concentration at which there is mortality of 50% of a group of specific test species) for the three biocides.

Table 6-37: Summary of dewatering discharge modelling parameters

Parameter	Value
Maximum discharge volume	96,710 m^3
Maximum flow rate	280 m^3/hour
Discharge duration	345.5 hours
Outlet pipe internal diameter	26 inch
Depth of pipe below sea surface	248.5 m
Height of pipe above seafloor	3.5 m
Discharge salinity	33.9 practical salinity units/ppt
Discharge water temperature	12.7 °C–12.8 °C (variation based on ambient mean seasonal considerations)
Initial biocide concentration	Gluteraldehyde – 1,250 mg/L THPS – 550 mg/L Hydrosure 0-3670R – 550 mg/L

Modelling results

In summary, the modelling results (RPS 2017d) showed:

- Overall, the area influenced by the dewatering discharge was localised to the vicinity of the release location during all seasons.
- Contact with shoals/banks, reefs and islands, AMPs or KEFs was not predicted during any season.
- The near-field results showed that due to the relative weak currents at the discharge depth (248.5 m), in combination with the lack of density and temperature differences between the dewatering plume and receiving environment (which would otherwise promote plume mixing and thus dilution), the plume maintained a low profile immediately above the seafloor, whilst drifting horizontally from the release location.
- Due to the limited seasonal variability of ambient water column conditions near the seabed the seasonal near-field modelling results demonstrated no discernible difference in the plume behaviour between summer, winter and transitional seasons.
- Within 100 m from the discharge location, the minimum average dilution of the plume ranged from 1:32 to 1:58 under strong and weak currents, respectively.
- The diameter of the dewatering plume near the seabed ranged between 6.1 m and 20.4 m at 100 m from the discharge location.
- A dilution level of 1:1,250 (or 1 ppm of the Glutaraldehyde biocide concentration) was predicted at a maximum distance of approximately 1.27 km from the discharge location for all seasons (**Figure 6-15**).
- A dilution level of 1:550 (or 1 ppm of the THPS and Hydrosure 0-3670R biocide concentration) was predicted at a maximum distance of approximately 0.92 km from the discharge location for all seasons (**Figure 6-15**).
- Based on the 1:1,250 and 1:550 dilution contours, the dewatering discharge was predicted to cover approximately 1.14 km2 and 0.75 km2 for all seasons, respectively.
- Considering the maximum distance of the 1:1,250 and 1:550 dilution contours and the location of the closest shoals/banks, no toxic impacts associated with residual biocide concentration are expected to non-transitory environmental values/sensitivities.

Refer to **Appendix K** for the full modelling report.

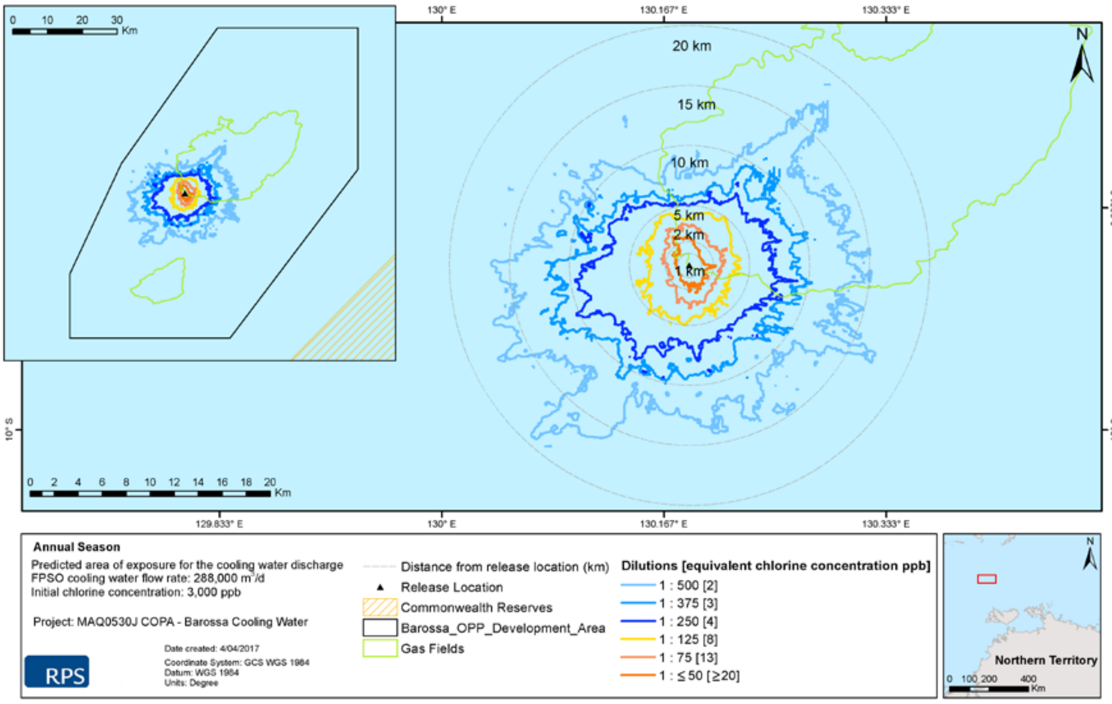


Figure 6-15: Predicted extent of the dewatering biocide concentration dilutions

Impact assessment and risk evaluation

The addition of biocides, corrosion inhibitors, scale inhibitors and oxygen scavengers to the flooding fluid is necessary in order to limit activity of corrosion inducing microbial and bacterial micro-organisms in the water to preserve long-term integrity of the gas export pipeline. While the toxicity of biocides, corrosion inhibitors, scale inhibitors and oxygen scavengers is influenced by the specific type of chemical product, ConocoPhillips' preference to select low toxicity chemicals, which still meet technical requirements, will reduce the potential for any risks to the marine environment to a low level.

The selection of chemical products within the dewatering discharge stream will be subject to a chemical assessment process, as described in **Section 4.3.5.8**. Products that are rated as Gold or Silver under the OCNS CHARM model or have a OCNS group rating of D or E (i.e. are considered inherently biodegradable and nonbioaccumulative) are considered suitable for use and controlled discharge to the marine environment is permitted. Products that do not meet these criteria will only be considered following assessment and approval. The Gluteraldehyde and THPS biocides are rated as Gold or Silver (Centre for Environment, Fisheries and Aquaculture Science (CEFAS) 2017), are readily biodegradable and do not bioaccumulate (Dow 2013, 2010). Hydrosure 0-3670R is not currently listed under the OCNS CHARM model, however other comparable Hydrosure products are Gold or Silver rated chemicals (CEFAS 2017). Based on a review of Hydrosure 0-3670R and testing on analogous substances containing the same active chemical component as Hydrosure (e.g. quaternary ammonium chloride or alkyl dimethyl benzyl ammonium chloride), the components were not found to bioaccumulate and displayed a degradation rate or half-life in seawater of 8–15 days (i.e. biodegradable) (Chevron 2015). The acute toxicity (96 hour LC50¬) for Hydrosure has been reported at 1 ppm (Chevron 2015).

While biocide is the predominant chemical constituent of interest in the dewatering discharge, other chemicals will also be present within the discharge stream and have the potential to interact with the marine environment. Ethylene glycols, such as MEG and TEG, form a homogeneous mixture with water, do not volatilise nor undergo photodegradation, and are not adsorbed on to soil particles (Hook and Revill 2016). Studies on a green alga (*Chlorella tusca*), a freshwater crayfish (*Procambarus sp.*) and a golden orfe carp (*Leuciscus idus melanotus*) revealed low potential for bioaccumulation of ethylene glycols in the marine environment (International Programme on Chemical Safety 2000). Ethylene glycols biodegrade readily when released to the environment, and several strains of micro-organisms are capable of using ethylene glycol as a carbon source. Evans and David (1974) studied the biodegradation of ethylene glycol in four samples of river water under controlled laboratory conditions. The samples were dosed with 0 mg/L, 2 mg/L or 10 mg/L of ethylene glycol and incubated at two temperatures (20°C or 8°C). At 20°C, primary biodegradation was complete within three days in all four samples, while at 8°C, it was complete after 14 days. Water temperatures near the seabed in the Barossa offshore development area generally range between approximately 11– 13°C (Jacobs 2016a) and therefore biodegradation is expected to be occur within two weeks.

The INPEX Ichthys EIS presented LC50 values (i.e. concentration at which there is mortality of 50% of a group of specific test species) for the effects of MEG on various aquatic species ranging from 5,000 ppm (goldfish, *Carassius auratus*) to 180,624 ppm (brine shrimp, *Artemia salina*) for a 24-hour exposure period. Other studies have reported the toxicity of MEG as being 10,000 ppm (48 hr LC50 for algae and Daphnia; 96 hr LC50 for fish) (RPS 2017d). The high LC50 values indicate low toxicity to aquatic species. Further, MEG and TEG are ranked as gold or silver (depending on the chemical supplier) under the OCNS CHARM ranked list of notified chemicals and are considered inherently biodegradable, non-bioaccumulative and suitable for discharge to the marine environment (CEFAS 2017). Given the low residual concentrations of hydration inhibitors of MEG/TEG expected, rapid biodegradation and low toxicity, no significant impacts are expected to the marine environment.

The dewatering discharge associated with the project is expected to result in a localised and temporary decline in water quality immediately above the seabed. The biocide concentration is expected to dilute to below ecological threshold concentrations within approximately 1.27 km from the discharge location for all seasons and biocide types (**Figure 6-15**). The area potentially affected by the plume above the threshold ranged between 0.75 m^2 to 1.14 km^2 for all seasons and biocides. As shown by the modelling, the dewatering plume is not expected to rise up through the water column, but move horizontally immediately across the seabed.

Based on the modelling results, the area influenced above ecological thresholds from the dewatering discharge is limited to the open offshore waters within the Barossa offshore development area. The dewatering plume is not expected to impact non-transitory environmental values/sensitivities, such as the surrounding shoals and banks, as the nearest feature is approximately 27 km from the Barossa offshore development area. There are no known BIAs, breeding grounds or sensitive habitats critical to EPBC-listed species within the Barossa offshore development area. While individuals of marine fauna may pass through the area, they are unlikely to come into contact with the dewatering discharge for any significant periods of time. Given the dispersion characteristics of the plume and the transient movement of marine fauna, exposure times of sufficient duration that may lead to toxic effects are not expected. The majority of marine fauna species (e.g. turtles, whales, sea snakes, fish) are also generally present within pelagic waters and are not known to dive regularly to these depths (see **Section 5.6**). Therefore, contact with the discharge plume is unlikely as they are expected to transit the area above the plume. The likelihood of potential impacts is also further reduced by the temporary nature of the discharge (approximately 14.5 days).

As the plume is expected to travel in close proximity to the seabed, there is the potential for localised exposure of benthic habitats and associated species within the vicinity of the discharge location. There are sparse benthic communities within the Barossa offshore development area with the seabed consisting of soft sediments. No protected or sensitive benthic habitats have been identified with the potential to be exposed to the dewatering plume. The dewatering discharge is not expected to contact the KEF of the shelf break and slope of the Arafura shelf as the values associated with unique seafloor feature were not observed to occur in the Barossa offshore development area during the Barossa marine studies program, nor are these topographically distinct features evident from the bathymetry data derived from previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across this area.

Therefore, the risk of the plume contacting the sensitive benthic habitat values associated with the KEF is improbable. Any potential impacts to benthic communities from the dewatering discharge are expected to be a minor and temporary, given the localised area affected and the short-term nature of the discharge.

Although commercial fisheries overlap the Barossa offshore development area, consultation to date has not identified any areas of peak fishing activity in the vicinity of the project. In addition to this, given the nature and scale of the dewatering discharge (a non-continuous discharge over a number of days which affects a small area near the seabed) and limited exposure expected to targeted commercial fish species, impacts to commercial fisheries are considered to be insignificant.

6.4.8.7 Other planned discharges

Brine

Brine generated from RO units used to create potable water for use on the FPSO facility will be routinely discharged to the marine environment throughout the life of the project. The discharged brine will have an elevated salinity concentration (approximately 30% higher than the intake seawater) and will tend to sink in the water column because of its higher density. The brine will be subject to rapid dilution and dispersion as a result of the prevailing ocean currents that exist within the Barossa offshore development area. Considering this, the small volumes released (approximately 96 m^3 per day) and that the brine is only approximately 30% more saline than the marine environment, the discharge is expected to return to background salinity levels within a short distance from the discharge location (within a few metres). Therefore, the potential to affect marine fauna that may be transiting through the area is highly unlikely.

Most marine species are also able to tolerate short-term fluctuations in salinity of 20–30% (Walker and McComb 1990). Therefore, it is expected that any pelagic species (including marine mammals, marine reptiles, fish, sharks and rays) passing through the denser saline brine discharge would not experience any adverse impacts.

Pigging

Pigging activities will be undertaken throughout the life of the project on a routine basis for a number of purposes including maintenance and infrastructure integrity. Pigging at the tie-in location is of relevance given its proximity to Shepparton Shoal. Pigging activities at the tie-in location may be undertaken once every 2–5 years each pigging operation will result in very small volumes (< 5 m^3) of dry gas, corrosion inhibitor and inhibited seawater or MEG being released to the marine environment. No solids are expected to be released during pigging activities. Given the limited frequency of these activities and the very small volume associated with the release, impacts to Shepparton Shoal are anticipated to be negligible.

Hydrotest water

Discharged hydrotest water from the in-field flowlines and gas export pipeline will have very similar characteristics to the dewatering discharges associated with the project. Hydrotest water will consist of filtered inhibited seawater containing residual chemicals, which may include biocides, corrosion inhibitor, scale inhibitor and oxygen scavengers. It is also possible that hydrate inhibitors (e.g. MEG and TEG) may be introduced to aid in drying and pre-conditioning of the gas export pipeline.

The volume of hydrotest water to be discharged is significantly smaller than the dewatering discharge and is expected to be in the order of approximately 3,000 m^3 (refer **Section 4.3.5.8**). The largest single, one-off discharge of approximately 1,300 m^3 will be associated with hydrotesting of the gas export pipeline and be discharged at the sea surface, at either the FPSO facility end of the export pipeline or at the Bayu-Undan pipeline tie-in end of the export pipeline. The discharge of hydrotest water is expected to cause a localised and temporary decline in water quality in the upper water column. As with the dewatering discharge, biocides are considered to be the predominant chemical constituent of interest within the hydrotest discharge as they have the highest toxicity to marine receptors. As discussed in **Section 6.4.8.6**, the types of biocides that may be used for the project are biodegradable and do not bioaccumulate.

The concentrations of the residual chemicals in the hydrotest discharge are expected to rapidly reduce through dilution and mixing processes driven by ocean and tidal currents, and winds. Therefore, while the initial concentrations of the chemicals may be above ecological thresholds (see **Section 6.4.8.6**) in the immediate surrounds of the discharge location they are expected to rapidly reduce to levels below these threshold concentrations. Consequently, and considering the short discharge duration (< 1 day), the likelihood of the hydrotest discharge plume contacting marine fauna or the upper reaches of any shoals/banks (e.g. Shepparton Shoal) at toxic concentrations for periods of time that may lead to toxic effects (e.g. 96 hour LC50) is remote. The discharge plume will not interact with the seabed given the surface nature of the release, and therefore the likelihood of impacts to benthic habitats is considered improbable.

Although commercial fisheries overlap the project area, consultation to date has not identified any areas of peak fishing activity within, or in the vicinity of, the project. In addition to this, given the nature and scale of the hydrotest discharge (i.e. a single, one-off surface release for less than 1 day) and limited exposure expected to commercial fish species, impacts to commercial fisheries are considered to be negligible.

As outlined in **Section 6.4.8.6**, a chemical assessment process will be implemented for the project to help ensure that any potential environmental impacts resulting from chemical use and discharge are minimised. Considering the controls that will be implemented, and the nature and scale of the hydrotest discharge, the risk to the marine environment is considered low.

Impact and risk summary

In conclusion, the residual risk of impact to the marine environment as a result of planned discharges associated with the project is considered low given the location of the Barossa offshore development area in open, ocean waters which are distant to shoals/banks and biologically important areas for marine fauna, and the relatively localised or short term duration of the discharges.

The project is considered consistent with the relevant requirements of the Blue Whale Conservation Management Plan, Recovery Plan for Marine Turtles in Australia and relevant marine fauna species conservation advices as related to planned discharges (**Table 6-38**). A summary of the potential impacts, proposed management control measures, acceptability and EPOs for planned discharges are presented in **Table 6-39**.

Table 6-38: Summary of alignment with relevant EPBC management plans for planned discharges

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Marine mammals - Blue whale	Blue Whale Conservation Management Plan (October 2015) (DoE 2015a)	Demonstrably minimise anthropogenic threats, including habitat modification through acute/chronic chemical discharge.	• The discharge extent for all planned discharges is localised and rapid dilution is predicted to occur within the deep offshore waters, reaching levels below those that may cause harm to marine species within the Barossa offshore development area. • There are no significant feeding, breeding or aggregation areas for marine mammals within the Barossa offshore development area. • The implementation of the key management controls, including the establishment of discharge limits and environmental monitoring program for PW and cooling water, and the application of a chemical selection process, will minimise the area influenced by planned operational discharges.
Marine mammals - Sei whale Marine mammals - Fin whale	Conservation advice (October 2015) (DoE 2015c) Conservation advice (October 2015) (DoE 2015d)	Pollution (persistent toxic pollutants) has been identified as a threat to sei and fin whales, however, no specific actions or requirements have been defined.	
Marine reptiles – Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017- 2027 (June 2017) (DoEE 2017a)	Minimise chemical discharge. Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of the species. Marine anthropogenic activities in biologically important areas to ensure that biologically important behaviour can continue.	• The discharge extent for all planned discharges is localised and rapid dilution is predicted to occur within the deep offshore waters, reaching levels below those that may cause harm to marine species within the Barossa offshore development area. • There are no significant feeding, breeding or aggregation areas for marine turtles within the Barossa offshore development area. • The implementation of the key management controls, including the establishment of discharge limits and environmental monitoring program for PW and cooling water, and the application of a chemical selection process, will minimise the area influenced by planned operational discharges. • No planned discharges are proposed from the gas export pipeline during operations. Therefore, no interactions of operational discharges with the flatback or olive ridley internesting BIAs or habitat critical to the survival of these species is expected. It is concluded that the implementation of management controls will allow the activities to be managed to ensure marine turtles are not displaced from identified habitat critical to their survival and that biologically important behaviour can continue.

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Birds - Red knot	Conservation advice (May 2016) (DoE 2016f)	No specific actions or requirements are identified for pollution/contamination for this species.	• The discharge extent for all planned discharges is localised and rapid dilution is predicted to occur within the deep offshore waters, reaching levels below those that may cause harm to marine species within the Barossa offshore development area. • There are no significant feeding, breeding or aggregation areas for the red knot within the Barossa offshore development area. • The species is capable of flying non-stop along their migratory route and tends to use only a few staging areas (Bamford et al. 2008, cited in DoE 2016f). Therefore, the red knot is unlikely to interact frequently, if at all, with waters in the project area. • The implementation of the key management controls, including the establishment of discharge limits and environmental monitoring program for PW and cooling water, and the application of a chemical selection process, will minimise the area influenced by planned operational discharges.
Sharks and rays - Great white shark	Recovery Plan for the White Shark (*Carcharodon carcharias*) (August 2013) (DSEWPaC 2013a)	No specific actions or requirements are identified for assessing the threat of habitat modification/degradation for these species from pollution, as relevant to the project.	• The discharge extent for all planned discharges is localised and rapid dilution is predicted to occur within the deep offshore waters, reaching levels below those that may cause harm to marine species within the Barossa offshore development area. • There are no significant feeding, breeding or aggregation areas for sharks within the Barossa offshore development area. • The implementation of the key management controls, as outlined above, will minimise the area influenced by planned operational discharges.
Sharks and rays - Grey nurse shark	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (August 2014) (DoE 2014a)		
Sharks and rays - Speartooth shark Northern river shark Green sawfish Largetooth sawfish Dwarf sawfish	Sawfish and River Sharks Multispecies Recovery Plan (November 2015) (DoE 2015j) Conservation advice: speartooth shark (April 2014) (DoE 2014b), northern river shark (April 2014) (DoE 2014c), dwarf sawfish (October 2009) (DEWHA 2009) and green sawfish (2008) (DEWHA 2008b)	Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification.	

Table 6-39: Summary of impact assessment, key management controls, acceptability and EPOs for planned discharges

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
Planned discharges	Physical environment – water quality and sediment quality. Shoals and banks. KEFs – shelf break and slope of the Arafura Shelf.	Localised and temporary reduction in water quality associated with increased turbidity, water temperature or salinity leading to impacts to marine fauna. Localised displacement, smothering (mainly associated with discharge of drill fluids and cuttings) or toxicity of benthic habitats/ communities that are regionally widespread.	*General* All planned discharges from vessels will comply with relevant MARPOL 73/78 and Australian Marine Order requirements (as appropriate for vessel classification). All planned operational discharges will be managed in accordance with a project Waste Management Plan (and as detailed in activity-specific EPs). Pre-installation surveys will be undertaken to confirm the FPSO facility is not located in the vicinity of areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles) and nearby shoals and banks (including Lynedoch Bank, Tassie Shoal and Evans Shoal, all > 27 km away). A maintenance program will be developed and implemented for the FPSO facility which includes inspection and maintenance of treatment systems to confirm discharge limits are met. All chemicals (hazardous and non-hazardous) used on the FPSO facility will undergo a HSE assessment and be approved prior to use. The HSE assessment required by the procedure aims to identify and control health and environmental risks during transport, use and storage of the chemicals. The procedure includes: • definition of key roles and responsibilities • the process for approvals and registration of chemicals • key requirements for safe transport, handling and storage. ConocoPhillips will confirm that the selection of chemical products within the planned discharge streams that are discharged to the marine environment are subject to a chemical assessment process. Products that meet at least one of the following environmental criteria are considered suitable by ConocoPhillips for use and controlled discharge to the marine environment is permitted: • rated as Gold or Silver under OCNS CHARM model • if not rated under the CHARM model, have an OCNS group rating of D or E (i.e. are considered inherently biodegradable and non-bioaccumulative).	The potential impacts and risks associated with planned discharges from the project are considered broadly acceptable given: • The residual risk of impact from planned discharge of drill cuttings and WBM fluids in the Barossa offshore development area is considered low given the relatively short duration of development drilling, the fact that discharge of sediment is contained within the Barossa offshore development area where no significant benthic communities have been identified, and no contact is predicted with the closest shoals/ banks. Impacts beyond temporary minor effects to water quality (e.g. turbidity increase) and localised burial, smothering and displacement of commonly represented benthic habitats and communities are not anticipated.	All planned operational discharges from the FPSO facility: • will not exceed the natural variation of existing baseline water quality conditions for temperature and hydrocarbons, and mercury or chlorine concentrations outside the Barossa offshore development area, and • will not impact areas of seabed that are associated with the seafloor features/ values of KEFs or the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (located > 27 km away from the Barossa offshore development area, which is beyond the outer boundary of planned operational discharges), and

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			The use of products that do not meet these criteria will only be considered following assessment and approval through a chemical assessment process, as outlined above. The assessment will also be informed by an environmental risk assessment which will help ensure that any potential environmental impacts resulting from chemical use and discharge are minimised. *Drill fluids* No planned discharge of whole SBM will occur overboard. When using SBM, the solids control equipment will reduce the residual base fluid on cuttings content prior to discharge overboard. Residual base fluid on cuttings will be less than 10% by weight (w/w), averaged over all well sections drilled with SBM. *PW and cooling water* An environmental monitoring program (**Section 7.2.3**) and adaptive management framework (**Section 7.3**) will be applied to manage PW and cooling water discharges. Mercury levels in PW discharge will be subject to monitoring during operations to confirm that concentrations remain within acceptable discharge limits. PW and cooling water will be discharged below the sea surface to maximise dispersion Development of a predicted mixing zone(s) for PW and cooling water within the Operations EP, as informed by modelling and validation studies.	• The residual risk of impact from planned discharge of PW, cooling water, wastewater and brine is considered low given that the discharge extent is localised and strong currents and mixing within the open ocean environment are predicted to cause rapid dilution, reaching levels below those which may cause harm to marine species within the Barossa offshore development area. Therefore, contact with shoals/banks, reefs and islands, AMPs or KEFs was predicted to be highly unlikely. The potential for impact associated with the bioaccumulation of PW, cooling water or wastewater constituents in benthic sediments is considered low and limited to a potential localised effect on a limited number of benthic fauna species immediately surrounding the FPSO facility. • The residual risk of impact from planned dewatering discharge is considered low given the expected area of influence associated with the discharge is localised within the Barossa offshore development area, exposure is of a short term duration, and the nature of benthic habitats and associated species within the vicinity of the FPSO facility are represented elsewhere.	• meet relevant ANZECC/ ARMCANZ and/or natural variation in ambient baseline conditions (where determined to be more relevant to the site-specific context to derive reference values) beyond the predicted mixing zone(s). Dewatering discharges will not extend beyond the Barossa offshore development area and will not impact areas of seabed that are associated with the seafloor features/ values of KEFs or the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			During operations, verification monitoring and reporting of temperature and chlorine concentrations of the cooling water discharge stream and hydrocarbon concentrations of the PW discharge stream will be undertaken prior to discharge. Residual chlorine levels in the cooling water discharges will comply with a target of concentration of less than or equal to 3 ppm at the point of discharge to maintain safe operations. The temperature of the cooling water discharge plume from the FPSO will return to within 3 °C of the ambient temperature within 100 m of the discharge point PW discharges will have a hydrocarbon content that is no greater than an average of 30 mg/L over any 24-hour period. The OIW concentration of PW will be continuously monitored by an installed OIW analyser which will be fitted with an alarm that activates if OIW concentration is > 30 mg/L. Baseline, periodic and 'for cause' (e.g. exceedance of contaminants) toxicity testing of PW discharges will be undertaken against the recognised ecotoxicity assessment methodology defined in ANZECC/ARMCANZ (2000).	• The residual risk of impact from planned hydrotest discharge is considered low given the expected area of influence associated with the discharge is localised, exposure is of a short term duration and there is no predicted contact with the seabed. • The key management measures are considered effective at managing the risks. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements (e.g. OPGGS Act 2006, MARPOL 73/78 and Marine Orders, ConocoPhillips Chemical Management Procedure, North Marine Bioregion Plan). • The project aligns with applicable management/recovery plans and conservation advices. **Table 6-38** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5**. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level.	All discharges of SBM residual base fluid on cuttings from drilling activities will be below 10% w/w oil-on-cuttings averaged over all well sections drilled with SBM. Reduce impacts to the marine environment from planned discharges through the application of a chemical assessment process, which includes an environment risk assessment.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			Dewatering of flooding fluid The location of the dewatering discharge will be selected to minimise impact on areas of regional environmental importance (e.g. shoals, banks, coral reefs, islands, etc.) to the extent practicable. Flooding fluid chemicals (e.g. biocide, oxygen scavengers and dye) will be selected for environmental performance (i.e. low toxicity chemicals), whilst maintaining technical performance requirements, and follow the chemical assessment process (as detailed above). The dewatering of flooding fluid will be detailed in the relevant activity-specific EPs developed during the detailed engineering and design studies for the project. The EPs will detail dewatering requirements, including definition of discharge characteristics (i.e. chemical additives and concentrations), discharge location and volumes, methodology and species thresholds. *MEG stream* The FPSO facility will have facilities that will regenerate and reclaim MEG for re-use or onshore disposal, if continuous MEG injection is used for flow assurance. *Wastewater and other planned discharges* Oily bilge water from machinery space drainage is treated to a maximum concentration of 15 ppm OIW prior to discharge from vessels, as specified in MARPOL 73/78 (Annex I). Offshore discharge of sewage from vessels will be in accordance with MARPOL 73/78 (Annex IV) and Marine Order 96. Food wastes from vessels will be macerated to < 25 mm diameter prior to discharge, in accordance with MARPOL 73/78 (Annex V) and Marine Order 95. Detailed performance criteria for planned discharges will be defined in the activity-specific EPs.		

6.4.9 Waste management

Over the course of the project life-cycle, a range of solid and liquid wastes will be generated that will require responsible management. The risk assessment for potential impacts to the marine environment arising from inappropriate management of general solid non-hazardous or hazardous wastes is shown in **Table 6-40**.

Table 6-40: Waste management risk assessment

Risk	Inappropriate management of non-hazardous or hazardous waste.		
Geographic project reference	Barossa offshore development area, gas export pipeline corridor		
Key project stage	All		
Key factor(s) (see Table 6-7)	Physical environment (water quality)	Marine reptiles	
	Marine mammals		
Other relevant factor(s) (see Table 6-7)	Birds	Sharks and rays	
	Fish		
Potential impact(s)	• Temporary and localised reduction in water quality, i.e. pollution or contamination of the marine environment. • Interaction of marine fauna with solid wastes, such as plastic packaging, which may result in physical injury or mortality (through ingestion or entanglement) of the individual.		
Risk assessment			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	1 Negligible (Bio)	2 Remote	2 Low
Residual risk	1 Negligible (Bio)	2 Remote	2 Low
Confidence	High		

Impact assessment and risk evaluation

General wastes will be produced throughout the life of the project and may include domestic wastes (such as paper, plastic, bottles, scrap materials) and industrial/operational wastes (such as chemicals, chemical drums, waste oil, mercury removed during offshore processing on the FPSO facility and consumables).

The unplanned discharge of solid (hazardous and non-hazardous) waste as a result of inappropriate storage or handling/transfer is likely to result in minor impacts only. Attempts to recover wastes or dropped objects will be made where safe and practicable to do so. Non-buoyant materials not able to be recovered are expected to sink to the seabed within the immediate vicinity of the project and cause a small, localised impact to benthic habitats. However, as discussed in **Section 6.4.2**, the infauna and macrofauna communities and benthic habitat in the Barossa offshore development area is known to be generally uniform and consistent with that associated with deep water environments, and are representative of the broader Bonaparte Basin and Timor Sea. Buoyant materials, which are mostly inert and non-hazardous, have the potential to impact marine fauna individuals through ingestion or entanglement as they transit the area. Good housekeeping practices will be implemented on all project vessels, therefore reducing the risk of accidental over board discharge of solid waste on marine fauna.

Depending on the option selected for mercury removal, mercury disposed may be in solid (contained within absorbent beads) or liquid (if condensed in gas drums) form (**Section 4.3.3.1**). Irrespective of the form of mercury, it will be appropriately packaged and transported to shore for disposal at an approved facility. The frequency of disposal depends on the option selected and may range between every few months to once every 4–5 years. Given the management of mercury and the controls that will be implemented throughout operations, it is highly unlikely that it will be accidentally released and therefore the exposure risk to the receiving marine environment is extremely low. Considering the waste management controls that will be implemented and enforced through auditing and reviews, and the location of the majority of the project in the open ocean, it is considered highly unlikely that waste will result in significant impacts to key values and sensitivities, including EPBC protected species.

Should an unplanned liquid discharge (e.g. chemicals or waste oil) occur to the marine environment, the discharged fluids would be subject to rapid dispersion and dilution as a result of the prevailing ocean currents that exist within the project area. Given the typical small volumes and temporary (i.e. instantaneous) duration of accidental discharge events, impacts to water quality would be temporary and highly localised. Subsequently, there would be limited potential for toxicity to marine fauna due to temporary exposure and low toxicity as a result of rapid dilution. Therefore, any potential impacts to marine fauna would be limited to any individuals that may be transiting within the immediate area of the discharge (within tens to several hundred metres). However, the likelihood of this is very low considering the majority of the project area does not contain any significant feeding, breeding or aggregation areas for marine fauna. While the southern end of the gas export pipeline corridor overlaps a portion of internesting habitat critical to the survival of flatback and olive ridley turtles, impacts are still considered highly unlikely given the highly localised and temporary nature (only relevant to installation and periodic maintenance/inspection activity) of the potential unplanned event. No contact with the Tiwi Islands is expected as the gas export pipeline corridor is approximately 6 km from the coastline at its closest point and taking into account the preventative controls and response framework that will be implemented. A detailed evaluation of potential impacts associated with large-scale unplanned liquid discharges is provided in **Section 6.4.10**.

Impact and risk summary

In conclusion, the residual risk of impact from unplanned discharge of liquid or solid waste to the marine environment is considered low given the management controls, low likelihood of occurrence and the nature of the existing environment in the immediate vicinity of project activities (e.g. no areas of significant feeding, breeding or aggregation for marine fauna).

The project is considered consistent with the relevant requirements of the Blue Whale Conservation Management Plan, Humpback Whale Recovery Plan 2005-2010 (under review), Recovery Plan for Marine Turtles in Australia, Whale Shark Recovery Plan 2005-2010, Sawfish and River Sharks Multispecies Recovery Plan and relevant marine fauna species conservation advices as related to waste management (**Table 6-41**). A summary of the potential impacts, proposed key management controls, acceptability and EPOs for waste management are presented in **Table 6-42**.

Table 6-41: Summary of alignment with relevant EPBC management plans for waste management

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Marine mammals - Blue whale	Blue Whale Conservation Management Plan (October 2015) (DoE 2015a)	Demonstrably minimise anthropogenic threats, including habitat modification through marine debris.	• Good housekeeping practices will be enforced through auditing and reviews, and applied at all stages of the project, to minimise the risk of impact from marine debris. • There are no significant feeding, breeding or aggregation areas for marine mammals, whale sharks, river sharks, sawfish or birds within the project area that would be subject to impacts from marine debris from project activities. • Marine debris will not be intentionally introduced to the marine environment during installation or operation of the pipeline. In the unlikely event of an unplanned release of waste/marine debris (specifically within the habitat critical to the survival of flatback and olive ridley turtles during installation of the gas export pipeline), it will not represent a significant contribution to marine debris or associated habitat degradation, and no population level impacts are expected as a result of the activities. It is concluded that the implementation of management controls will allow the activities to be managed to ensure marine turtles are not displaced from identified habitat critical to their survival and that biologically important behaviour can continue.
Marine mammals - Humpback whale[1]	Humpback Whale Recovery Plan 2005-2010 (May 2005) (under review) (DEH 2005a) Conservation advice (October 2015) (DoE 2015b)	No specific actions or requirements are identified for assessing the threat of marine debris.	
Marine reptiles – Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (June 2017) (DoEE 2017a)	Reduce the impacts from marine debris.	
		Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of the species.	
		Manage anthropogenic activities in biologically important areas to ensure that biologically important behaviour can continue.	
Fish - Whale shark	Whale Shark Recovery Plan 2005-2010 (May, 2005) (May 2005) (DEH 2005b) Conservation advice (October 2015) (DoE 2015i)	No specific actions or requirements are identified for assessing the threat of marine debris.	
Birds - Curlew sandpiper	Conservation advice (May 2015) (DoE 2015e, f) (notes that the threats are particularly relevant to eastern and southern Australia)	No specific actions or requirements are identified for habitat loss and degradation from pollution for these species.	
Birds - Eastern curlew			
Birds - Australian Lesser noddy[2]	Conservation advice (October 2015) (DoE 2015g)		

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Birds - Great knot[2]	Conservation advice (May 2016) (DoE 2016a)		
Birds - Greater sand plover[2]	Conservation advice (May 2016) (DoE 2016b)		
Birds - Lesser sand plover[2]	Conservation advice (May 2016) (DoE 2016c)		
Birds - Western Alaskan bar-tailed godwit[2]	Conservation advice (May 2016) (DoE 2016d)	Protect important habitat in Australia.	
Birds - Northern Siberian bar-tailed godwit[2]	Conservation advice (May 2016) (DoE 2016e)		
Birds - Red knot[2]	Conservation advice (May 2016) (DoE 2016f)		
Sharks and rays - Great white shark	Recovery Plan for the White Shark *(Carcharodon carcharias)* (August 2013) (DSEWPaC 2013a)		
Sharks and rays - Grey nurse shark	Recovery Plan for the Grey Nurse Shark *(Carcharias taurus)* (August 2014) (DoE 2014a)	No specific actions or requirements are identified for assessing the threat of habitat modification/degradation for these species from pollution, as relevant to the project.	
Sharks and rays - Speartooth shark Northern river shark Green sawfish Largetooth sawfish Dwarf sawfish	Sawfish and River Sharks Multispecies Recovery Plan (November 2015) (DoE 2015j) Conservation advice: speartooth shark (April 2014) (DoE 2014b), northern river shark (April 2014) (DoE 2014c), dwarf sawfish (October 2009) (DEWHA 2009) and green sawfish (2008) (DEWHA 2008b)	Reduce and, where possible, eliminate any adverse impacts of marine debris.	

[1] Although the species were identified in the EPBC Protected Matters search they are highly unlikely to occur in the project area, which is outside the species range or preferred habitat (see **Section 5.6.2** for humpback whales). However, the species may occur within the area of influence.

[2] These species were identified only in the area of influence EPBC Protected Matters search.

Table 6-42: Summary of impact assessment, key management controls, acceptability and EPOs for waste management

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome

Waste management	Physical environment – water quality.
	
	Marine mammals.
	
	Marine reptiles.
		Temporary and localised reduction in water quality, i.e. pollution or contamination of the marine environment.
		
		Interaction of marine fauna with solid wastes, such as plastic packaging, which may result in physical injury or mortality (through ingestion or entanglement) of the individual.
			All wastes generated offshore will be managed in accordance with relevant legal requirements, including MARPOL 73/78 and Australian Marine Order requirements (as appropriate for vessel classification).
			
			A project Waste Management Plan will be developed and implemented, and will include details of:
			• the types of waste that will be generated by the project and will require containment, transport to, and disposal at, a licensed facility onshore
			• management protocols for the handling, segregation and responsible disposal of wastes. For example, non-hazardous and hazardous solid and liquid wastes will be transported safely to shore and disposed onshore at licensed treatment and disposal facilities.
			• measurable performance criteria
			• competency and training
			• audits, reporting and review, including compliance checks via waste manifests.
			
			Hydrocarbon and chemical storage and handling procedures will be implemented, including:
			• secure storage of bulk hydrocarbons and chemicals in areas with secondary containment
			• storage of hydrocarbon and chemical residues in appropriate containers
			• stocks of SOPEP spill response kits readily available to respond to deck spills of hazardous liquids and personnel trained to use them
			• planned maintenance system including maintenance of key equipment used to store and handle hydrocarbons/chemicals (e.g. bulk transfer hoses, bunding)
			• MSDS available on board for all hazardous substances.
				The potential impacts and risks associated with inappropriate waste management are considered broadly acceptable given:
				• The residual risk of impact is considered low as:
				  • the likelihood of occurrence and the nature of the existing environment in the immediate vicinity of project activities (e.g. no areas of significant feeding, breeding or aggregation for marine fauna)
				  • any potential impacts to local water quality are likely to be for a short duration only.
				  • good housekeeping practices will be implemented on all project vessels, therefore reducing the risk of accidental overboard discharge of wastes on the receiving environment.
					Zero unplanned discharge of hazardous and non-hazardous wastes into the marine environment as a result of project activities.
					
					Hazardous waste will be transported onshore for treatment and/or disposal at licenced treatment and disposal facilities.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			Non-hazardous and hazardous wastes will be managed, handled and stored in accordance with their MSDS, and tracked from source to their final destination at an appropriately licensed waste facility. Heavy lifting operations between vessels and the MODU/drill ship or FPSO facility will be undertaken using competent personnel and certified lifting equipment and accessories to minimise the risk of dropped objects.	• The key management measures are considered effective at managing the risk and will be enforced through auditing and reviews. EPOs specific to this aspect are framed to achieve sustainable management of impacts and risks. • The proposed management controls are determined to be appropriate to manage the risk to an acceptable level. • The project aligns with relevant legislative requirements, standards, industry guidelines and ConocoPhillips requirements (e.g. MARPOL and Marine Orders, relevant recovery plans). • The project aligns with applicable management/recovery plans and conservation advices. **Table 6-41** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5**.	

6.4.10 Unplanned discharges

There is a low probability risk of release of unplanned discharges (i.e. hydrocarbon or chemical spills) to the marine environment through unplanned events such as a refuelling/bunkering incident, vessel collision or long-term well blowout. The risk assessment for potential impacts to the marine environment is summarised in **Table 6-43**.

The risk assessment presented below is considered highly conservative as it is based on low likelihood largest maximum credible spill scenarios, with no spill response measures taken, of:

- long-term well blowout in the Barossa offshore development area that could occur during development drilling or operations and result in the discharge of condensate
- large-scale release of intermediate fuel oil (IFO) from a pipelay vessel due to a vessel collision during installation of the gas export pipeline, in close proximity to the Tiwi Islands.

ConocoPhillips has successfully undertaken previous appraisal drilling campaigns in the Barossa offshore development area and will apply the same responsible approach to managing the risk of unplanned releases for the project.

The industry has learnt a lot in terms of the assessment, preventative management and response in the unlikely event of a major release. These learnings have been incorporated into the management framework and key management controls presented in this OPP.

Table 6-43: Unplanned discharges risk assessment

Risk	Unplanned discharge of hydrocarbons or chemicals to the marine environment.	
Geographic project reference	Barossa offshore development area, gas export pipeline corridor	
Key project stage	All. The low likelihood long-term well blowout scenario is considered to represent the maximum credible spill scenario associated with spills that may occur in the Barossa offshore development area (i.e. has the greatest area of influence). The low likelihood scenario of a pipelay vessel collision is assessed as representing the maximum credible spill scenario associated with spills that may occur along the gas export pipeline route, and is only applicable during installation of the pipeline.	
Key factor(s) (see Table 6-7)	Physical environment (water quality and sediment quality)	Birds
	Shoals and banks	Fish
	Tiwi Islands	Sharks and rays
	Other offshore reefs, islands and NT/WA mainland coastline	Commercial fishing
	Marine mammals	Recreational and traditional fishing (Tiwi Islands)
	Marine reptiles	
Other relevant factor(s) (see Table 6-7)	Plankton	Tourism, recreation and scientific research
	AMPs	Commercial shipping
	KEFs	Offshore petroleum exploration and operations
	Commonwealth Heritage places	Defence activities
	Marine archaeology	

Potential impact(s)	• Reduction in water quality. • Direct toxic or physiological effects on marine biota, including corals, mammals, reptiles, birds, fish and sharks/rays. • Hydrocarbon/chemical contact with shoals/banks, reefs and islands at concentrations that result in adverse impacts. • Alteration of biological communities as a result of the effects on key marine biota. • Socio-economic impacts on marine archaeology, commercial fishing, traditional fishing (with particular reference to the Tiwi Islands), tourism, recreation and scientific research, and commercial shipping.		
Risk assessment			
Barossa offshore development area			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	4 Significant (Bio)	2 Remote	8 Medium
Residual risk	4 Significant (Bio)	2 Remote	8 Medium
Gas export pipeline			
	Consequence	*Likelihood*	*Risk rating*
Inherent risk	4 Significant (Bio)	2 Remote	8 Medium
Residual risk	4 Significant (Bio)	2 Remote	8 Medium
Confidence	High		

6.4.10.1 Overview of maximum credible hydrocarbon spill scenarios

A number of maximum credible spill scenarios resulting in the unplanned release of hydrocarbons to the marine environment associated with the project were identified and are summarised in **Table 6-44**. In determining the scenarios, particular focus was placed on identifying risks associated with development drilling, installation of the gas export pipeline, and operation of the FPSO facility and associated activities with the potential to result in the release of a significant volume of hydrocarbons to the marine environment. The AMSA Technical Guidelines for preparing contingency plans for marine and coastal facilities (AMSA 2015) were also taken into consideration when defining the credible spill scenarios and maximum credible spill volumes.

The consequence ranking for each scenario was informed by the modelling outputs that provide an indication of the extent and severity of potential impact, combined with information identified in **Section 5** regarding the existing environment and key environmental values/sensitivities. Comprehensive quantitative three-dimensional hydrocarbon spill modelling (stochastic and deterministic), including predictions of surface films, entrained hydrocarbons and dissolved aromatic hydrocarbons, has been undertaken by RPS APASA to assess the risk of exposure to the sea surface and the surrounding shoals/banks, offshore reefs and islands from these scenarios (RPS 2017e).

The likelihood rating was informed by historical spill data to determine event probability and the collective knowledge and experience of the subject matter experts involved in the risk assessment process. Likelihood was ranked in accordance with the process outlined in **Section 6.2.3.2**. Event probability for each scenario was determined through referral to a range of publicly available sources that cite likelihood probabilities for hydrocarbon spills with similar characteristics as those identified in **Table 6-44**. Key sources reviewed included the DNV Final Report Assessment of the Risk of Pollution from Marine Oil Spills in Australian Ports and Waters for the Australian Maritime Safety Authority (2011), the Browse Upstream EIS (Woodside 2011), Browse FLNG EIS (Woodside 2014) and the Ichthys EIS (INPEX 2010). While references cited do not provide directly comparable spill release scenarios, they are indicative within the same order of magnitude of the likely probabilities of release for the Barossa project context. For example, INPEX (2010) cites a loss of containment probability for a vessel collision with an FPSO facility. This probability has been used to support the likelihood rating allocated by subject matter experts in the risk assessment for Scenarios 2, 3, 5 and 6 in **Table 6-44**, given the nature of the scenario is similar (i.e. related to vessel collisions in offshore waters).

Table 6-44: Summary of maximum credible hydrocarbon spill scenarios

Maximum credible spill scenario	Location	Description	Hydrocarbon type and volume	Spill duration	Risk assessment			
					Consequence	Likelihood	Event Probability	Residual risk rating
1	Barossa offshore development area – FPSO facility[1]	Refuelling incident	Marine diesel – 10 m^3 surface release	Instantaneous	1 Negligible	4 Probable	1.38 x 10^{-2} to 4.9 x 10^{-2} (once every 20–72 years)	4 Low
2		Vessel collision leading to loss of a single FPSO facility fuel tank	Marine diesel[2] – 2,975 m^3 surface release	6 hours	2 Minor	2 Remote	3.0 x10^{-4} (once in 3,333 years)	4 Low
3		Vessel collision leading to loss of a single FPSO facility condensate storage tank[3]	Barossa condensate – 19,400 m^3 surface release	6 hours	3 Moderate	2 Remote	3.0 x10^{-4} (once in 3,333 years)	6 Medium
4		Long-term well blowout	Barossa condensate – 16,833 m^3 or 210.1 m^3/day subsea release	80 days	4 Significant	2 Remote	1.33 x 10^{-5} to 8.4 x 10^{-4} (once in 1,190 – 75,188 years)	8 Medium
5		Vessel collision leading to loss of an offtake tanker fuel tank	Heavy fuel oil (HFO) – 650 m^3 surface release	6 hours	3 Moderate	2 Remote	3.0 x10^{-4} (once in 3,333 years)	6 Medium
6	Gas export pipeline – nominal location close to Bathurst Island[4]	Vessel collision leading to loss of a single pipelay vessel fuel tank	IFO-180 – 500 m^3 surface release	6 hours	4 Significant	2 Remote	3.0 x10^{-4} (once in 3,333 years)	8 Medium

[1] As the project is still in the early design phase, the location of the FPSO facility (as shown in **Figure 4-2**) is indicative and may be subject to refinement as engineering design progresses. Therefore, for the purposes of the modelling a conservative location closest to the nearest shoals/banks of Evans Shoal and Tassie Shoal was selected to assess the potential impacts and risks associated with unplanned releases from the FPSO facility. The modelling location is approximately 8.1 km south-west of the indicative FPSO facility.

[2] The FPSO facility may also be fuelled by marine gas oil – see further discussion below in **Section 6.4.10.4**.

[3] Scenario 3 was used to provide a conservative evaluation for the scenario of a vessel collision leading to the loss of Barossa condensate from an offtake tanker cargo tank. Based on a review of standard, globally-used offtake tankers, the largest offtake tanker cargo tank size is expected to be in the order of 10,000 m^3 to 14,000 m^3. This is well within the volume that is represented by Scenario 3 (19,400 m^3) and the spill duration is expected to be the same. While the residual risk rating for a vessel collision with an offtake tanker while it is within the Barossa offshore development area is likely to be lower than for the scenario of a collision with the FPSO facility, given the offtake tanker is expected to be required approximately every 80–100 days. For the purposes of this early stage assessment, the residual risk rating is conservatively assumed to be the same.

[4] A nominal location close to the Tiwi Islands (i.e. Bathurst Island) was selected to provide an estimate of the maximum potential environmental impacts and risks from a vessel collision during installation of the gas export pipeline.

It is important to note that the maximum credible spill volumes modelled for the vessel collision scenarios resulting in the loss of hydrocarbons to the marine environment in the Barossa offshore development area (Scenarios 2, 3 and 5) or along the gas export pipeline (Scenario 6) are considered highly conservative as they assume:

- large vessels, such as the offtake tanker, are travelling at speeds that are likely to result in severe damage to the FPSO facility, offtake tanker or pipelay vessel
- failure of multiple key controls, such as standard navigational, safety and in-field/installation vessel speed requirements
- significant damage to structural integrity occurs. The level of damage required for the modelled scenarios to occur is only considered possible in a situation where an errant vessel has lost capacity to control both its speed and course and failed to respond or provide radio warnings.

The scenarios modelled are considered to provide a credible representation of the types and volumes of hydrocarbons and possible release locations associated with the project (including potential future development of the Caldita Field with or without a WHP; **Section 4.3.1**). The definition of these scenarios has allowed for a rigorous evaluation of all potential impacts to a vast range of key regionally important values and sensitivities (e.g. shoals/banks, reefs, shorelines, AMPs, marine fauna, habitat critical to the survival of flatback and olive ridley turtles, BIAs, commercial fishing areas), and therefore, has informed the overall determination of environmental consequence and acceptability for the project in relation to unplanned discharges. These scenarios also represent a range of spill volumes which allow for appropriate planning and assessment of emergency response capabilities and resources. It is recognised that other spill scenarios may be identified as the project becomes more defined and these will be assessed in activity-specific EPs. Given the conservative nature of the maximum credible spill scenarios modelled, it is anticipated that the other spill scenarios will be either representative or a subset of the area of influence assessed within this OPP. As outlined in **Section 5.1**, the assessment of risks/impacts in the OPP is based on the largest area of influence associated with a long-term blowout and pipelay vessel collision at the southern end of the gas export pipeline. The full extent of the area of influence has been taken into account in the assessment of potential impacts, as a conservative approach. Therefore, the scenarios modelled allow for the comprehensive assessment of a wide range of different environmental and socio- economic values/sensitivities that may occur in the marine environment.

While the overarching objective of the modelling was to assess the impacts and risks to regionally relevant values/sensitivities, such as submerged shoals/banks, offshore islands and reefs, the impact and risk evaluation also takes into account the key values and sensitivities, as informed by **Section 5**, which includes MNES, marine mammals, marine reptiles, birds, corals and socio-economic values/sensitivities.

A preliminary analysis and evaluation of a potential subsea release of gas from the gas export pipeline, which is considered to be of very low likelihood, has also been considered as part of the OPP. Refer to **Section 6.4.10.13** for further details on the scenario considered, and the potential impacts and risks.

Spill volumes and release duration

Spill volumes and release durations for the spill scenarios modelled were determined based on a review of:

- transfer hose inventory (volumes and flow rates) and spill prevention measures, including 'dry break' or 'break away' couplings, rapid shutdown of fuel pumps, to determine the volumes that would likely be released in the event of a refuelling incident. The spill duration was considered to be almost instantaneous (i.e. in the order of minutes) as shutdown mechanisms would be triggered instantly and refuelling rapidly stopped.
- hydrocarbon volumes (fuel and condensate) stored within FPSO facility. Based on the review, the fuel type and size of the storage tanks were considered to represent an appropriate upper order estimate for the various vessels that may be present in the Barossa offshore development area, such as heavy lift vessels and in-field or offshore support vessels. Given the size of the tanks and the expected release rate, the hydrocarbons are expected to be discharged over a period of approximately six hours.
- reservoir pressure and flow rates identified in the Barossa 2013/14 appraisal drilling campaign, to inform the volume of condensate that would be released as a result of a long-term well blowout. The spill duration was based on 80 days of continuous discharge from the well, which represents an indicative maximum predicted timeframe for the drilling of a relief well (as informed by the Montara wellhead platform well blowout that occurred in the Timor Sea in 2009).
- fuel types and storage tanks inventory of offtake tanker and pipelay vessels, to determine the maximum volumes that could be released as a result of a vessel collision with an offtake tanker during operations or pipelay vessel during installation of the gas export pipeline. The release duration assessed was approximately six hours, in alignment with the other vessel collision scenarios modelled.

While the potential well blowout scenario is based on the Barossa Field, well testing activities during the Caldita drilling program observed similar flow rates to that seen in the 2013/2014 Barossa appraisal drilling campaign. Therefore, it is considered that the modelling results for the Barossa condensate spill scenarios as discussed in this OPP provide an appropriate representation of the nature and scale of equivalent releases of Caldita condensate as there are no significant differences in terms of core inputs and parameters that underpin the modelling.

6.4.10.2 Modelling method

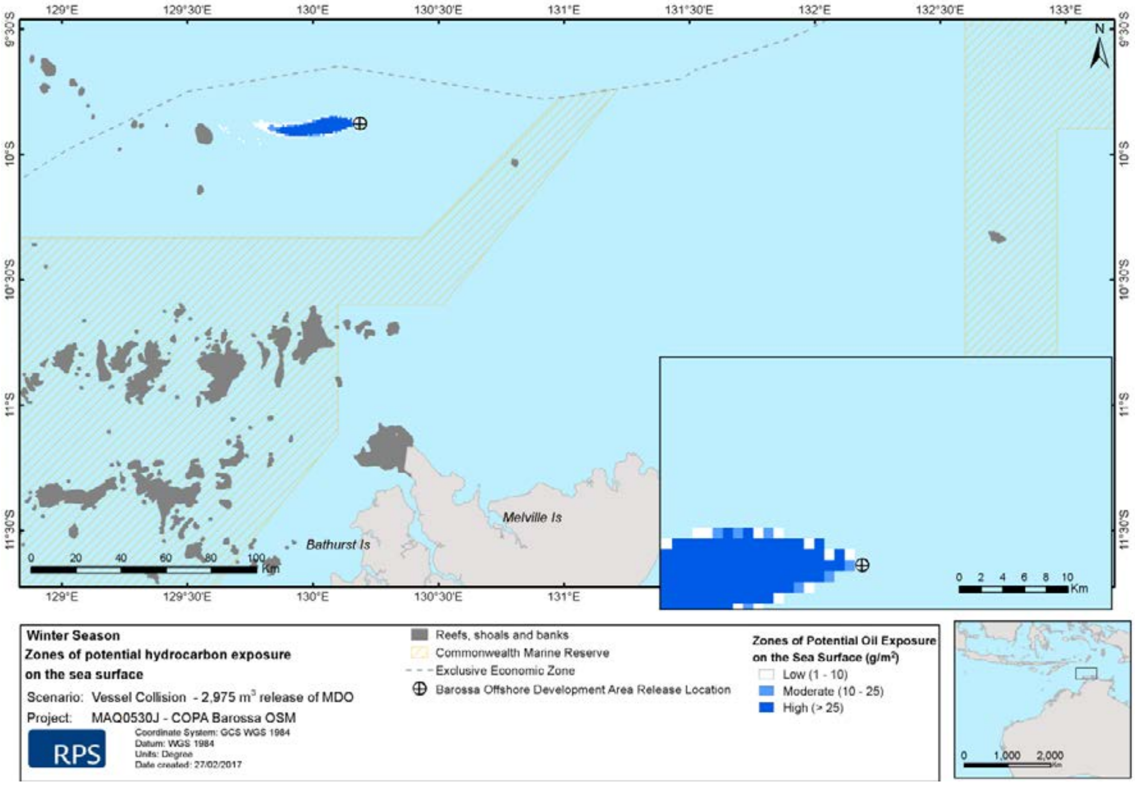
The hydrocarbon spill modelling study was undertaken in several stages. Firstly, a five-year ocean and tidal current dataset (2010–2014) was developed combining the influence of the ocean and tidal currents. Secondly, the currents, local winds and detailed hydrocarbon characteristics were entered into the three-dimensional spill model to replicate the drift, spread, weathering and fate of the spilled hydrocarbons. The model also considered the data collected during the extensive and robust Barossa marine studies program (**Section 5.2**). As outlined in **Section 6.4.8.1**, the modelling is considered highly representative of the characteristics influencing the marine environment, particularly within the Barossa offshore development area (RPS 2017e).

For each spill scenario, 100 single trajectories per season were modelled, with each trajectory characterised by the same spill information (i.e. release location, spill volume, duration and composition of hydrocarbons) but varying start times. This ensured that each spill trajectory was subjected to a range of varying wind and current conditions. Modelling was undertaken for each of the three distinct seasons to account for different combinations of wind, current and water temperatures that occur throughout annual cycles: summer (December to February), winter (April to August) and the transitional (March and September to November) seasons. This approach assists in identifying the key values and sensitivities that would be at risk of exposure on a seasonal basis.

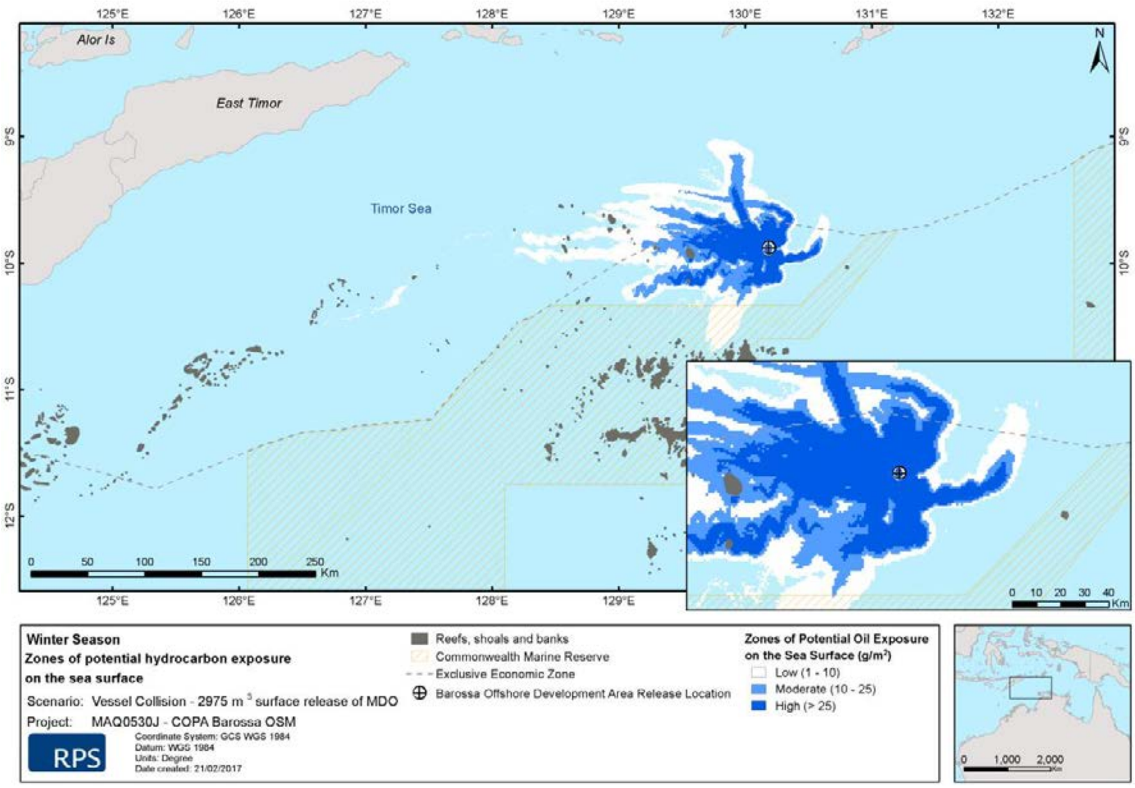
To assess the potential impacts to environmental values/sensitivities, the modelling results were reported against a series of defined sea surface, entrained and dissolved hydrocarbon thresholds. Further discussion on the thresholds applied to the modelling study is detailed in **Section 6.4.10.3** and **Appendix L**. To assess the potential impacts to submerged values/sensitivities, the modelling presented the probability of contact with entrained and dissolved hydrocarbons at depth specific intervals applicable for each value/sensitivity (RPS 2017e). For offshore reefs, shoals and banks, the model used the minimum depth of the feature while the surface water layer (0 m–10 m) was used for the AMPs (noting that at the time of the modelling study they were named Commonwealth Marine Reserves). The KEFs and commercial fisheries were assessed at different depths as relevant to the maximum depth layer modelled for the scenario. Potential impacts to the KEFs and commercial fisheries were assessed at depths of 40 m–50 m for Scenario 2 (vessel collision releasing marine diesel) as this was determined as the maximum depth to which the in-water component would extend. In the case of Scenario 3 (vessel collision releasing Barossa condensate) and Scenario 4 (long-term well blowout), a 90 m–100 m depth layer was assessed. The 90 m–100 m depth layer is considered an appropriate and conservative representation of potential impacts that may occur in benthic waters, within which the KEFs and commercial fisheries are located, and given the plume dynamics of a well blowout of Barossa condensate.

It is important to note that in interpreting the stochastic modelling, the results are calculated independently for each location from many simulations (i.e. 100 single spill trajectories per season). Therefore, the stochastic model output does not represent the actual extent of any single spill trajectory, but rather provides a summary of all trajectories run for each scenario and each season. In general, the potential extent and duration of exposure from an individual spill would be significantly smaller, shorter and unlikely to extend simultaneously over vast areas. An example of the difference in results between a single spill trajectory (i.e. deterministic modelling) and stochastic modelling outputs for the same scenario (2,975 m^3 surface release of marine diesel over six hours during winter conditions; Scenario 2) is shown in **Figure 6-16**.

The simulation lengths of the modelling runs were carefully selected for each scenario based on extensive sensitivity testing process (RPS 2017e). During the process, sample spill trajectories are run for longer than intended durations for each scenario and the results carefully assessed to examine the persistence of the oil (i.e. has the maximum evaporative loss been achieved for the period of time; and volume of hydrocarbons in the water column (if any)) in conjunction with the extent of sea surface exposure based reporting thresholds. The persistence of the hydrocarbons on the sea surface and entrainment within the water column is based on several factors including the nature of release (duration, volume and type (subsea or surface)), residual properties of the hydrocarbon type and weathering. Once there is alignment between these two factors the simulation length is deemed appropriate as the final fate of hydrocarbon is accounted for and the full exposure area is identified (RPS 2017e).



a) Deterministic modelling outputs – potential areas of sea surface exposure (at varying thresholds) from a single spill trajectory



b) Stochastic modelling outputs – potential areas of sea surface exposure (at varying thresholds) calculated from 100 spill trajectories

Figure 6-16: Comparison of spill modelling results at the same location from a single hydrocarbon spill simulation (deterministic modelling) with results from multiple simulations (stochastic modelling)

6.4.10.3 Sea surface, entrained and dissolved thresholds

As the model is able to track hydrocarbons to levels lower than biologically significant or visible to the naked eye, reporting thresholds have been specified to account for "exposure" on the sea surface and "contact" to environmental values/sensitivities at meaningful levels. Sea surface, entrained and dissolved hydrocarbon thresholds were defined based on available scientific literature and applied to the hydrocarbon spill modelling to assess the environmental impacts and biological consequences in the unlikely event of a hydrocarbon spill. These thresholds have been used to show the area that may be affected in the event of a spill, both in terms of contact and impact. The area that may be affected has been defined using low, moderate and high exposure zones, with the outer limit of the adverse exposure zone (i.e. area within which impact may occur) represented by the moderate threshold boundary. The high exposure threshold occurs within the moderate threshold boundary, and therefore presentation of the moderate exposure boundary represents a more conservative approach. This boundary also represents the outer limit of the area of influence as assessed in this OPP.

The thresholds for the surface, entrained and dissolved hydrocarbons, and their correlation with the zones of exposure and area of influence, are presented in **Appendix L.**

6.4.10.4 Hydrocarbon characterisation

This section provides an overview of the hydrocarbon characteristics, weathering properties and behaviour for the types of hydrocarbons which may be released as a result of the maximum credible spill scenarios identified for the project – marine diesel, Barossa condensate, HFO and IFO-180.

Refer to **Appendix L** for further description of the characteristics, fate and weathering of the hydrocarbons modelled.

Marine diesel

Marine diesel is a mixture of volatile and persistent hydrocarbons with low viscosity (RPS 2017e). If released to the marine environment, marine diesel will spread quickly and thin out to low thickness levels, thereby increasing the rate of evaporation. Generally, up to approximately 60% of the hydrocarbon will evaporate over the first two days, depending upon the prevailing conditions and spill volume (RPS 2017e). Marine diesel also has a strong tendency to entrain into the upper water column (0 m–20 m) (and consequently reduce evaporative loss) in the presence of moderate winds (> 10 knots) and breaking waves (RPS 2017e). However, diesel re-surfaces when the conditions calm. Approximately 5% of the hydrocarbon is considered persistent and, therefore, unlikely to evaporate, and will decay over time (RPS 2017e).

Marine gas oil may be used by the FPSO facility. In addition, vessels refuelled in Australia are likely to operate on marine gas oil. The key characteristics (i.e. density and viscosity) of marine gas oil, which influence the behaviour, weathering and fate of the hydrocarbon, are broadly similar to marine diesel. However, it is important to note that marine gas oil has a higher volatile component in comparison to marine diesel and will, therefore, spread out and evaporate more quickly. Therefore, it is considered that modelling of a marine diesel spill provides a more conservative representation of the nature and extent of a potential spill of marine gas oil.

Barossa condensate

The physical-chemical properties of Barossa condensate were based on an assay obtained during the 2013/14 Barossa appraisal drilling campaign. The assay is considered to be representative of the reservoir characteristics of the Barossa Field (i.e. unprocessed, 'volatile enriched' condensate) and the composition used to determine the weathering characteristics of the Barossa condensate.

The condensate is characterised by a low viscosity and is considered a Group I oil (non-persistent), as per the grouping classification presented by the International Tanker Owners Pollution Federation (ITOPF), IMO and United States EPA/United States Coastguard (AMSA 2015). On release to the sea surface the condensate would rapidly spread and thin out resulting in a large surface area of hydrocarbon for evaporation (RPS 2017e). Group I oils (non-persistent) tend to dissipate completely through evaporation within a few hours (ITOPF 2015). Based upon the Barossa condensate assay, up to 57% of the hydrocarbon would evaporate over the first few hours, with up to 79% evaporated after two days when on the sea surface (RPS 2017e). Only 7% of the condensate is considered persistent, with breakdown of this component due to decay weathering processes. Barossa condensate released to the sea surface may also become entrained into the water column in the presence of moderate winds and breaking waves, however, it would re-surface under calm conditions (RPS 2017e).

For the subsea Barossa condensate release scenario (Scenario 4 – long-term well blowout) modelling was undertaken to understand the plume dynamics due to the amalgamation of gas and condensate. The gas and condensate from a well blowout is released at the seabed into the water column as a hot plume under high pressure. As a result, the blowout will initially behave like a jet, which dissipates in the water column over a short distance (< 5 m). Following this, the buoyancy of the gas and condensate mixture relative to the surrounding waters controls the plume rise until it penetrates the surface waters or loses its momentum. Modelling showed that the condensate would be expected to separate into droplets of variable sizes between 18.4 µm and 92.1 µm (RPS 2017e). The minimum time for the condensate droplets to reach the surface at concentrations above the minimum sea surface threshold (1 g/m^2) was approximately one-hour post release. However, due to varying wind and current conditions, smaller condensate droplets can remain in the water column for days or weeks before reaching the sea surface. Therefore, evaporation rates would initially be expected to be rapid during the early phase of the release scenario, where larger droplets surface, and then decline over time (RPS 2017e).

On release from the seabed, the plume is predicted to rise through the water column (average velocity of approximately 3 m per second) and rupture at the sea surface (RPS 2017e). Therefore, the concentration of entrained hydrocarbons is predicted to be greatest in the sea surface layer and lowest at the seabed. The maximum core diameter of the plume was predicted to be approximately 31 m (RPS 2017e).

On reaching the sea surface, the Barossa condensate would undergo a series of changes to appearance, colour and phase state as it weathers. Within 24 hours of release, the remaining condensate would be expected to be almost semi-solid at average sea surface temperature (RPS 2017e). As weathering on the sea surface continues, the weathered residues of the Barossa condensate would be mostly in the form of paraffins, which would remain afloat as the oil spread out and thinned while it continued to weather at sea. As the residues became solid, they would form thin, clear sheets and white crystalline 'pancakes' which would then begin to break up into small, white waxy flakes due to the action of the waves and wind over time (RPS 2017e).

Hydrocarbons that cause most of the "aquatic toxicity" are generally the smaller aromatic and soluble components of oil (one ring and two ring aromatics) or the PAHs (RPS 2017e). The low volatility fraction of the Barossa condensate contains very low levels of aromatics in the three ring and above PAHs. Therefore, the weathered residues of the condensate are not considered to present an ecotoxicological threat in the water column (RPS 2017e).

While the potential condensate release scenarios (Scenarios 3 and 4) are based on Barossa condensate, review of an assay obtained during the 2005 Caldita exploration drilling program has shown that the key physical-chemical properties (i.e. density and API gravity) of the Caldita condensate are comparable. The Caldita condensate, like Barossa condensate, is a Group I oil (non-persistent). The condensates are also very similar in composition in terms of the volatile and residual components. Based upon the Caldita condensate assay, up to 45% of the hydrocarbon would evaporate over the first few hours, with up to 75% evaporated after two days when on the sea surface. Only 12% of the condensate is considered persistent (refer to **Section 6.4.10.4** for details on the Barossa condensate). Given this, and the comparability of the physical chemical properties, the behaviour, weathering and fate of the hydrocarbons are expected to be similar. As part of the spill modelling study (RPS 2017e) further comparative analysis was also undertaken, including reviewing the results of the Barossa condensate ecotoxicity assessment (Jacobs 2017; refer below) to assess the comparability of the potential toxicity impacts from Barossa or Caldita condensate. Given the similarity of the condensates, especially the BTEX compounds which are known to contribute to toxicity (Barossa condensate – approximately 6.9% weight and Caldita condensate – approximately 5.3% weight), the review concluded that the Barossa condensate ecotoxicity study is representative of Caldita condensate. Refer to (RPS 2017e; **Appendix L** for further detail.

Ecotoxicity assessment of Barossa condensate

To inform the assessment of the potential for toxicity impacts from unweathered (i.e. fresh) and weathered Barossa condensate to sensitive marine biota, ConocoPhillips commissioned ecotoxicology tests on a broad range of representative taxa of ecological relevance for mainly tropical Australia (Jacobs 2017; **Appendix M**).

The ecotoxicity testing focused on the dissolved aromatic hydrocarbon concentration of the water accommodated fraction (WAF) as these hydrocarbons are more biologically available to organisms through absorption into their tissues when compared to entrained hydrocarbons (Jacobs 2017). The toxicity of the unweathered condensate was tested on a range of species and life stages, however, the weathered condensate was only tested on fish. This approach was taken following a review of the spill modelling results from the maximum credible spill scenarios and considered the hydrocarbon characteristics (i.e. weathering and fate) of the Barossa condensate (Jacobs 2017). Given the spill modelling did not predict any contact of the WAF at the nearest non-transient submerged values/sensitivities within 24 hours (the period in which the majority of the volatiles would be lost), it was considered that fish would be the most likely value/sensitivity to be exposed to the weathered condensate given the proximity of the Timor Reef Fishery (Jacobs 2017). To provide a conservative assessment of potential ecotoxicological effects on key values/sensitivities a weathering test period of 12 hours was selected for the toxicity tests.

The toxicity tests were undertaken in alignment with well-established and accepted standard test protocols developed by Ecotox Services Australia (Jacobs 2017). The laboratory-based toxicity tests used a range of WAF concentrations of unweathered and weathered condensate to expose the different test organisms. The ecotoxicology tests mainly focused on the early life stages of the test organisms when they are generally at their most sensitive to hydrocarbons (Jacobs 2017). The condensate sample tested was considered representative of the Barossa condensate.

Aliquots of the Barossa condensate sample were weathered using the Mackay Chamber Testing techniques for a 12 hour weathering period, with a wind speed of 5.5 m/s and water temperature of 28.8°C (Jacobs 2017). The weathering period and conditions (i.e. wind speed and water temperature) were informed by the Barossa marine studies program, understanding of the key environmental values/sensitivities, and review of results of the maximum credible spill scenarios. For example, weathering information was based upon the season in which spawning occurs for goldband snapper (January to April with a peak during March) as this is the key target species of the Timor Reef Fishery.

The WAF was prepared by combining a prescribed quality of weathered or unweathered condensate to filtered seawater (Jacobs 2017). The combined samples were mixed and then allowed to settle before the WAF was siphoned off. The WAFs were then diluted with filtered seawater to prepare the remaining test concentrations. **Table 6-45** provides a summary of the no observed effect concentration (NOEC) of the WAF for each test organism. All of the values were significantly > 1,000 ppb, with the exception of the sea urchin (fertilisation) test organism. Based on the tests, the 95% species protection threshold for unweathered Barossa-3 condensate was 1,146 µg/L (1.146 mg/L) (Jacobs 2017). In summary, the results showed that the unweathered and weathered (for fish) Barossa condensate had almost negligible chronic aquatic toxicity according to the Group of Experts on Scientific Aspects of Marine Environmental Protection (2002) classification (Jacobs 2017).

Based on the ecotoxicology tests, the dissolved aromatic thresholds applied in this OPP (**Appendix L**) are considered highly conservative for the Barossa condensate. Specifically, the threshold used to define the outer boundary of the adverse exposure zone for dissolved aromatic hydrocarbons for the purposes of the hydrocarbon spill modelling study (i.e. a concentration of 50 ppb is considered to represent the 95% species protection threshold; **Appendix L**) is approximately 23 times more conservative than that for the Barossa condensate (1,146 ppb for the 95% species protection threshold).

Chemical analysis of the Barossa condensate showed that the main difference between the unweathered and weathered condensate was the change in BTEX. The weathered condensate had much lower concentrations, particularly of benzene and toluene (Jacobs 2016). BTEX compounds are acutely toxic to aquatic organisms if exposure is sustained. Because of the volatility of BTEX, aquatic organisms typically only experience short exposure times in the order of 12 hours which may circumvent toxic effects. All of the PAHs analysed were below the laboratory detection limit, with the exception of naphthalene (Jacobs 2017).

Table 6-45: Summary of ecotoxicity tests for unweathered and weathered Barossa condensate

Test organism (life stage)	Exposure duration	NOEC (ppb or µg/L)
Unweathered Barossa condensate		
Microalgal (growth)	72 hours	6,670
Macroalgal (germination success)	14 days	1,673
Sea urchin (fertilisation)	1 hour	350
Sea urchin (larval development)	72 hours	14,060
Milky oyster (larval development)	48 hours	7,160
Copepod (development)	5 days	8,560
Sea anemone (pedal lacerate development)	8 days	28,040
Fish (imbalance)	7 days	15,830
Fish (growth – biomass)	7 days	15,830
Range		350–15,830
Average		10,908
Weathered Barossa condensate		
Fish (imbalance)	7 days	22,480
Fish (growth – biomass)	7 days	22,480
Average		22,480

HFO

HFO comprises of a high percentage of persistent components (approximately 83%) which will not evaporate. If released to the marine environment, HFO will initially remain as a liquid and the volatile components (1%) immediately lost via evaporation (RPS 2017e). The physical properties will change quickly as the lighter components evaporate and disperse, with the residual persistent component becoming semi-solid to solid at ambient temperatures. Weathering tests with HFO have shown that both the pour point and the viscosity of the hydrocarbon increase with time (by an average of two orders of magnitude within 96 hours of weathering). Once the pour point of oil exceeds the seawater temperature (within 9–12 hours during all seasons) the hydrocarbon weathers to a point where mostly solid non-spreading hydrocarbon remains (up to 70% of HFO remained as a solid residue even after the most extreme weathering tests).

Laboratory tests with the bunker fuel Bunker C crude oil, which has similar physical properties to the HFO modelled in this study, have shown that HFO does not form stable emulsions (RPS 2017e). Instead, when released to the marine environment, HFO rapidly takes up water over a short energy range and the stability of the water-oil mixture remains the same in that it does not stabilise with increasing energy. This behaviour is consistent with entrained water in hydrocarbon, where released hydrocarbon will first appear as a black viscous liquid with large water droplets and within one week will become separated into hydrocarbon and water as water energies abate (RPS 2017e).

The toxic potential of weathered HFO is low in comparison to marine diesel and condensate as weathered oil is insoluble and the bioavailable portion of the oil is rapidly lost through evaporation (RPS 2017e). However, the solid persistent residues can remain in the marine environment for extended periods, with the longevity dependent on the physio-chemical properties of the HFO. The heaviest fractions (> C20) often break into discrete patches and may float or sink depending on density relationships and become incorporated into soils or sediments (American Petroleum Institute 2012). Biodegradation can also deplete hydrocarbons on sediments and on the sea surface overtime (Lee et al. 2003).

IFO-180

IFO-180 consists mainly of low volatile and persistent hydrocarbons with high viscosity, which significantly limits large amounts of evaporation and dispersion. If released to the marine environment the light volatiles (1%) are rapidly lost via evaporation while the residual component (approximately 64%) is expected to become semi-solid to solid at ambient temperatures (RPS 2017e). IFO-180 does not tend to entrain in the upper water column based on the hydrocarbon characteristics.

IFO can form stable or meso-stable water-in-oil emulsions in which seawater droplets become suspended into the oil matrix (Fingas and Fieldhouse 2004). This process requires physical mixing (i.e. wave action) with the stability of the emulsion influenced by the properties of the hydrocarbon product, including viscosities and asphaltene and resin content. Stable emulsions generally have an average water content of approximately 80% after 24 hours and have been shown to remain stable for up to four weeks under laboratory and test tank conditions (Fingas and Fieldhouse 2004). Mesostable water-in-oil emulsions have an average water content of around 70% after 24 hours which decreases to approximately 30% after one week (Fingas and Fieldhouse 2004). Meso-stable emulsions generally become unstable within three days, as shown under laboratory conditions. Emulsification of IFO-180 will affect the spreading and weathering of the oil and increase the volume of oily material. If not within an emulsion state, the decay of IFO-180 is more rapid in comparison to condensates and marine diesel as microbial decay is generally faster for hydrocarbons with higher viscosity (RPS 2017e).

The toxic potential of IFO-180 is largely dependent on the properties it has been blended with but generally contains <10% distillate with the remaining 90% composed of HFOs. The volatile and soluble components include those that are responsible for producing most of the aquatic toxicity due to its bioavailability to marine organisms in the water column (RPS 2017e). Therefore, Barossa condensate and marine diesel are considered to have a higher aquatic toxicity potential in comparison to IFO-180. However, non-persistent components are short-lived and susceptible to evaporation and degradation. The weathered portion of IFO would behave similar to HFO. The residual components would eventually become insoluble in seawater and end up adhered to sediment or biota reducing the risk of acute toxicity.

6.4.10.5 Hydrocarbon spill modelling results

A summary of the key modelling outputs for each of the maximum credible scenarios is presented in the following sections. The presentation of the results focusses on the moderate sea-surface, entrained and dissolved aromatic thresholds as these are considered to define the outer boundary of the adverse exposure zone, and therefore, the area that may be affected by the spill scenario (i.e. area of influence). Refer to **Appendix L** for a detailed technical summary of the results.

6.4.10.6 Scenario 1: Refuelling incident (10 m³ marine diesel)

In summary, the stochastic modelling results showed:

- The maximum distance from the source for the sea surface adverse exposure zone is predicted to vary between seasons at approximately 1.4 km, 2.7 km and 3.0 km during summer, transitional and winter conditions, respectively.
- No contact is predicted with the sea surface films at shores, reefs or open waters of the AMPs for any threshold in any season. **Figure 6-17** shows the potential sea surface adverse exposure zone for all seasons.
- Contact is predicted by the sea surface adverse exposure zone with the open waters above the KEF of the shelf break and slope of the Arafura Shelf (a unique seafloor feature) in all seasons, as the Barossa offshore development area is located within the bounds of this KEF.
- No entrained or dissolved aromatic hydrocarbon exposure is predicted at any threshold in any season and therefore, no contact with submerged or in-water values/sensitivities is expected.

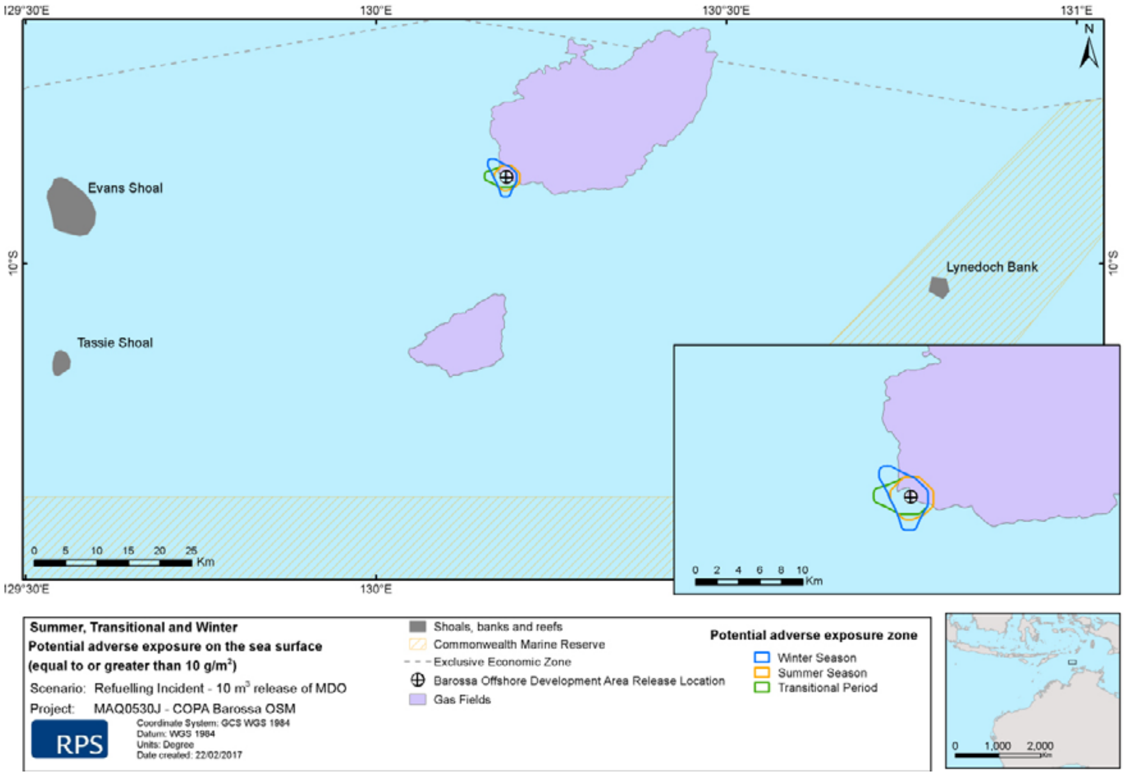


Figure 6-17: Stochastic modelling outputs showing the potential adverse exposure zone on the sea surface from a refuelling incident

6.4.10.7 Scenario 2: Vessel collision leading to loss of a single FPSO facility fuel tank (2,975 m^3 marine diesel)

In summary, the stochastic modelling results showed:

- The maximum distance from the source for the sea surface adverse exposure zone is predicted to vary between seasons at approximately 319 km, 392 km and 124 km during summer, transitional and winter conditions, respectively.
- Some contact is predicted at low probability (1–14% probability) by sea surface films within the adverse exposure zone with the surface waters above a number of submerged shoals/banks (total of 13) and KEF of the carbonate bank and terrace system of Van Diemen Rise, and the open waters of the Oceanic Shoals marine park, depending on the season (**Figure 6-18**).
- Contact by the sea surface adverse exposure zone with the waters above the KEF of the shelf break and slope of the Arafura Shelf (a unique seafloor feature) and open waters of the Timor Reef Fishery is predicted in all seasons, as the Barossa offshore development area is located within the bounds of these features.
- Contact is predicted (1–37% probability) by entrained hydrocarbons within the adverse exposure zone for various submerged shoals/banks (total of 25), open waters of the Oceanic Shoals, Arafura, Ashmore Reef and Cartier Island AMPs, waters above the KEFs of the shelf break and slope of the Arafura Shelf, carbonate bank and terrace system of Van Diemen Rise, pinnacles of the Bonaparte Basin, carbonate bank and terrace system of Sahul Bank and tributary canyons of the Arafura Depression, waters of the Timor Reef Fishery, and the Indonesian and Timor-Leste coastline, depending on the season (**Figure 6-19**).
- Some contact is predicted at low probability (1% probability) by entrained hydrocarbons within the adverse exposure zone at Ashmore Reef and Hibernia Reef during transitional conditions only.
- Some contact is predicted at low probability (1–2% probability) by dissolved aromatic hydrocarbons within the adverse exposure zone for 10 submerged shoals/banks, open waters of the Oceanic Shoals marine park, waters above the KEFs of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of Van Diemen Rise, and waters of the Timor Reef Fishery, depending on the season (**Figure 6-20**).
- No contact within the adverse exposure zone for sea surface, entrained or dissolved hydrocarbons is predicted with the NT/WA coastline or adjacent islands.

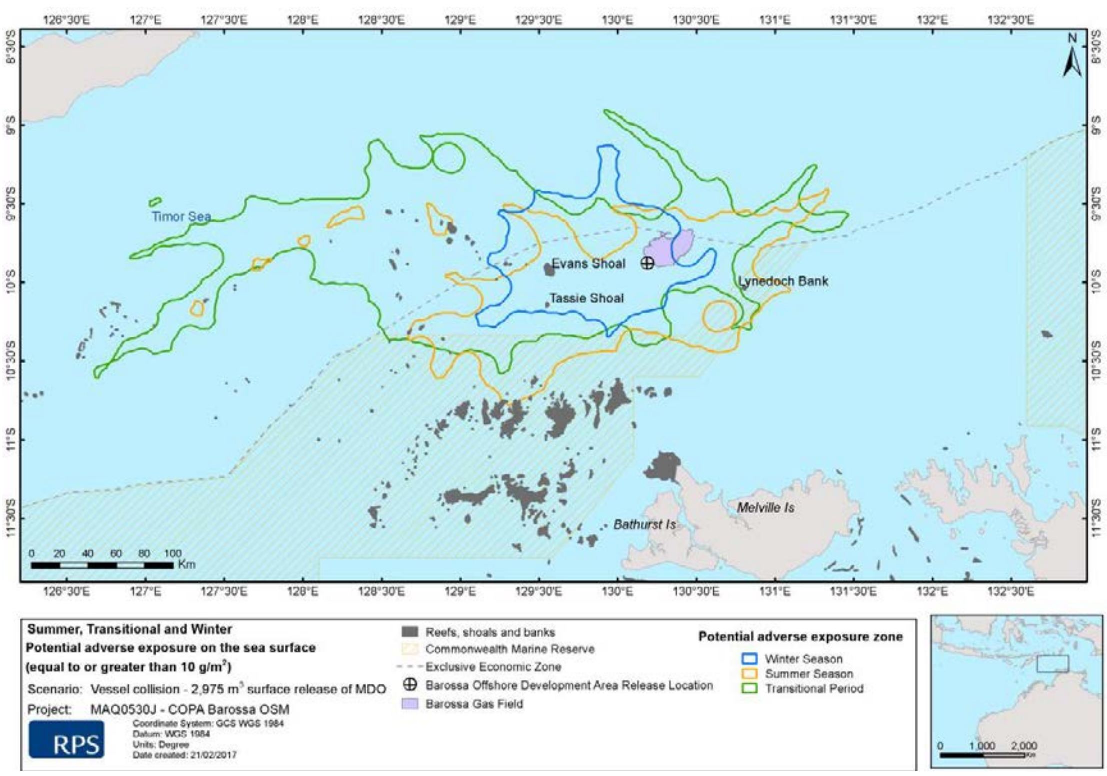


Figure 6-18: Stochastic modelling outputs showing the potential adverse exposure zone on the sea surface from a vessel collision releasing marine diesel

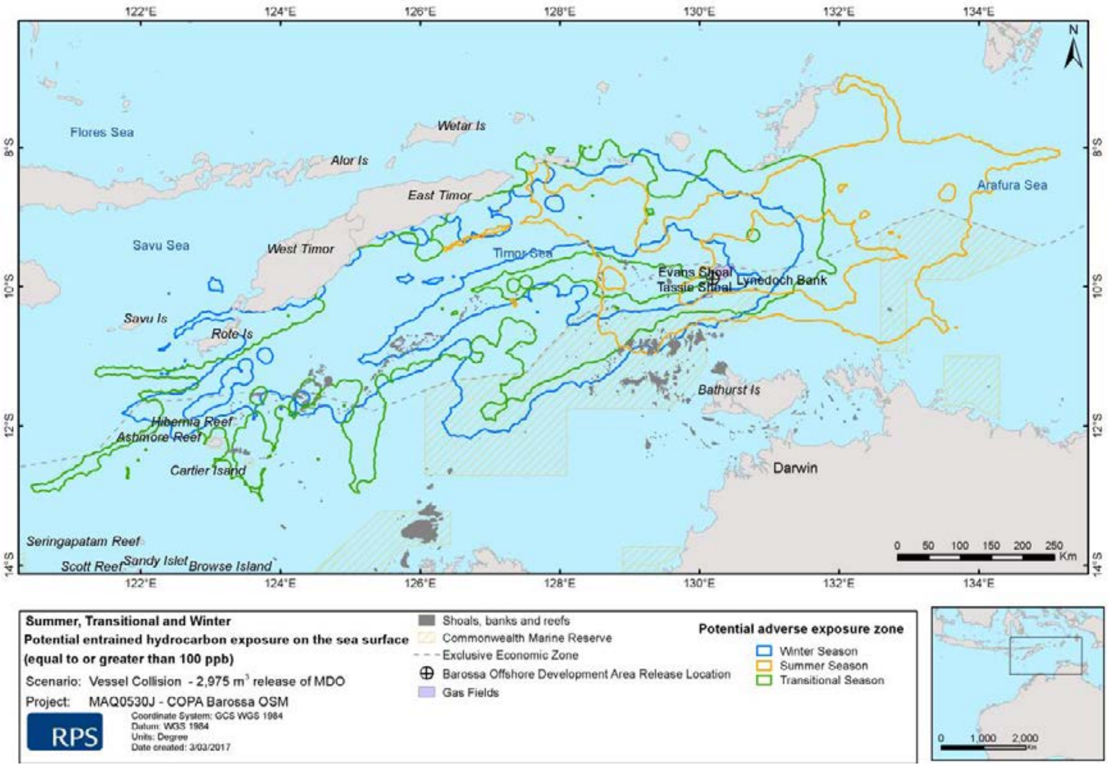


Figure 6-19: Stochastic modelling outputs showing the potential adverse exposure zone (0-10 m depth layer) for entrained hydrocarbons from a vessel collision releasing marine diesel

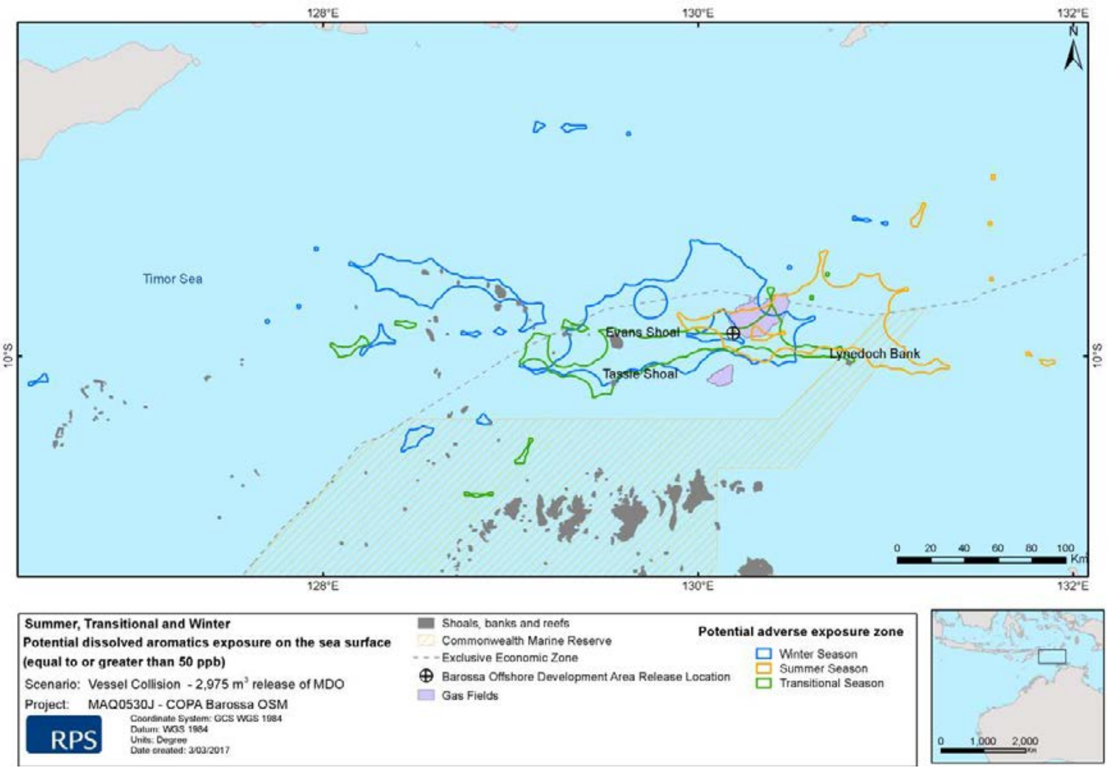


Figure 6-20: Stochastic modelling outputs showing the potential adverse exposure zone (0-10 m depth layer) for dissolved aromatic hydrocarbons from a vessel collision releasing marine diesel

6.4.10.8 Scenario 3: Vessel collision leading to loss of a single FPSO facility condensate storage tank (19,400 m^3 Barossa condensate)

In summary, the stochastic modelling results showed:

- The maximum distance from the source of the sea surface adverse exposure zone is predicted to vary between seasons at approximately 320 km, 560 km and 303 km during summer, transitional and winter conditions, respectively.
- Some contact is predicted at low probability (1–13% probability) by sea surface films within the adverse exposure zone with the surface waters above a number of submerged shoals/banks (total of 14), KEFs of the carbonate bank and terrace system of Van Diemen Rise and pinnacles of the Bonaparte Basin, and the open waters of the Oceanic Shoals marine park, depending on the season (**Figure 6-21**).
- Contact by the sea surface adverse exposure zone with the waters above the KEF of the shelf break and slope of the Arafura Shelf (a unique seafloor feature) and open waters of the Timor Reef Fishery is predicted in all seasons as the Barossa offshore development area is located within the bounds of these features.
- Contact is predicted (1–8% probability) by entrained hydrocarbons within the adverse exposure zone for various submerged shoals/banks (total of 24), Cartier Island, open waters of the Oceanic Shoals, Arafura, Ashmore Reef and Cartier Island AMPs, waters above the KEFs of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of Van Diemen Rise, waters of the Timor Reef Fishery, and the Indonesian and Timor-Leste coastline, depending on the season (**Figure 6-22**).
- Contact was predicted (1–36% probability) by dissolved aromatic hydrocarbons within the adverse exposure zone for various submerged shoals/banks (total of 23), open waters of the Oceanic Shoals and Arafura AMPs, waters above the KEFs of the shelf break and slope of the Arafura Shelf and tributary canyons of the Arafura Depression, waters of the Timor Reef Fishery, and the Indonesian coastline, depending on the season (**Figure 6-23**).
- No contact with the adverse exposure zone for sea surface, entrained or dissolved hydrocarbons was predicted with the NT/WA coastline or adjacent islands.

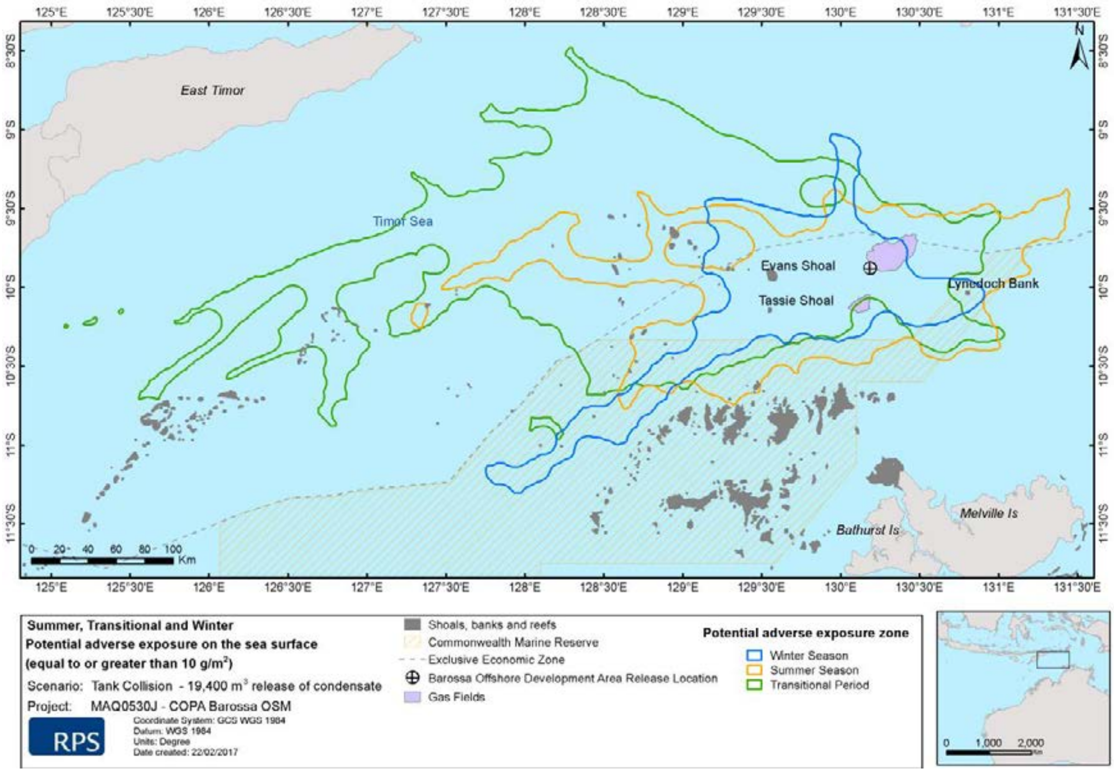


Figure 6-21: Stochastic modelling outputs showing the potential adverse exposure zone on the sea surface from a vessel collision releasing Barossa condensate

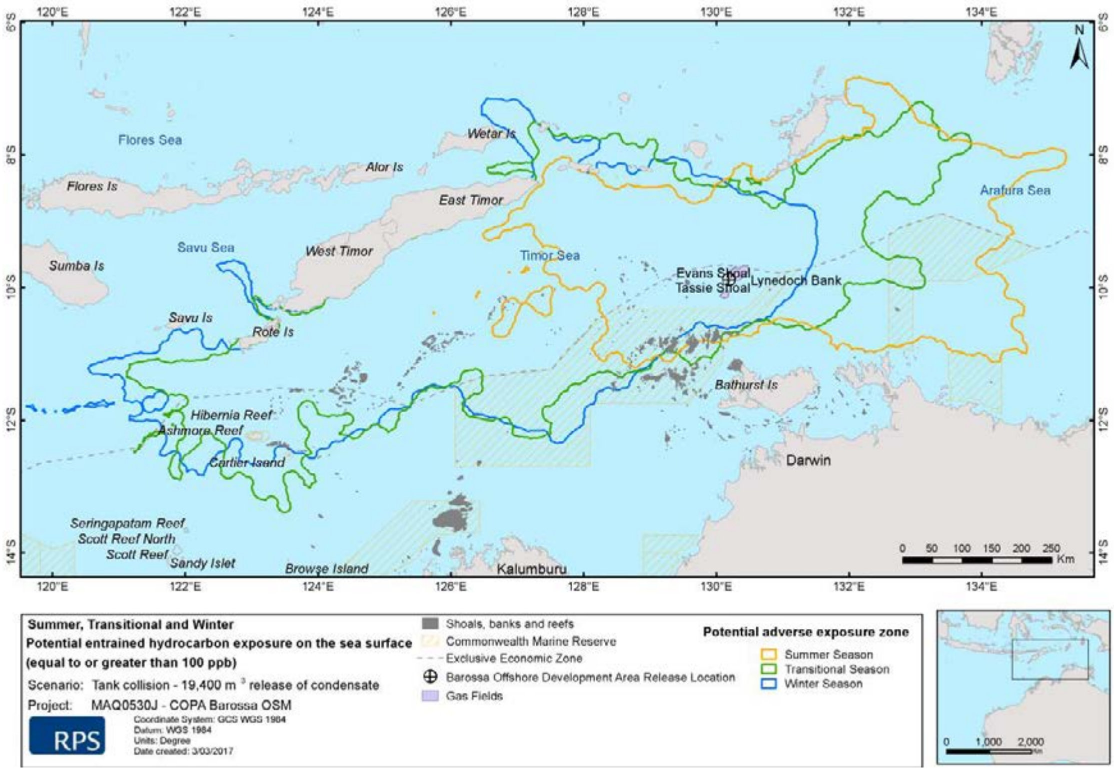


Figure 6-22: Stochastic modelling outputs showing the potential adverse exposure zone (0-10 m depth layer) for entrained hydrocarbons from a vessel collision releasing Barossa condensate

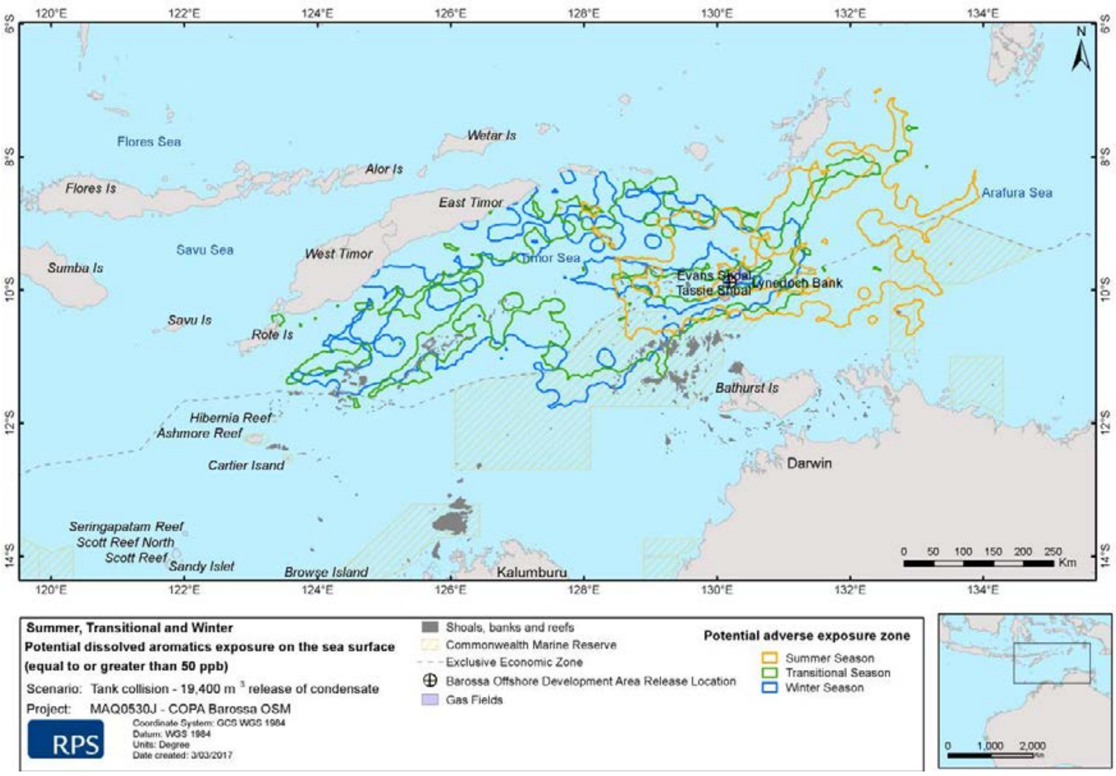


Figure 6-23: Stochastic modelling outputs showing the potential adverse exposure zone (0-10 m depth layer) for dissolved aromatic hydrocarbons from a vessel collision releasing Barossa condensate

6.4.10.9 Scenario 4: Long-term well blowout (16,833 m³ Barossa condensate)

In summary, the stochastic modelling results showed:

- The maximum distance from the source of the sea surface adverse exposure zone is predicted to vary between seasons at approximately 34 km (south-south-west), 227 km (west) and 17 km (east-north-east) during summer, transitional and winter conditions, respectively.
- No contact with waters above the various submerged shoals/banks for the sea surface adverse exposure zone was predicted during any seasonal conditions.
- Low probability of contact predicted (3%) by sea surface films within the adverse exposure zone with the surface waters above the KEF of the carbonate bank and terrace system of Van Diemen Rise, depending on the season (summer and transitional conditions only) (**Figure 6-24**).
- Contact by the sea surface adverse exposure zone with the waters above the KEF of the shelf break and slope of the Arafura Shelf (a unique seafloor feature) and open waters of the Timor Reef Fishery was predicted in all seasons as the Barossa offshore development area is located within the bounds of these features.
- Contact was predicted (variable ranging from 1–90% probability) by entrained hydrocarbons within the adverse exposure zone for various submerged shoals/banks (total of 35), Ashmore Reef, Cartier Island, Hibernia Reef, Seringapatam Reef, Scott Reef, open waters of the Oceanic Shoals, Arafura, Arnhem, Ashmore Reef, Cartier Island and Kimberley AMPs, KEFs of the shelf break and slope of the Arafura Shelf, carbonate bank and terrace system of Van Diemen Rise, carbonate bank and terrace system of Sahul Shelf, pinnacles of the Bonaparte Basin and continental slope demersal fish communities, waters of the Timor Reef Fishery, and the Indonesian and Timor-Leste coastline, depending on the season (**Figure 6-25**).
- Contact was predicted (1–74% probability) by dissolved aromatic hydrocarbons within the adverse exposure zone for various submerged shoals/banks (total of 31), Ashmore Reef, Hibernia Reef, open waters of the Oceanic Shoals, Arafura and Ashmore Reef AMPs, waters above the KEFs of the shelf break and slope of the Arafura Shelf, carbonate bank and terrace system of Van Diemen Rise, tributary canyons of the Arafura Depression, pinnacles of the Bonaparte Basin, carbonate bank and terrace system of the Sahul Shelf and continental slope demersal fish communities, waters of the Timor Reef Fishery, and the Indonesian and Timor-Leste coastline, depending on the season (**Figure 6-26**).
- No contact with the adverse exposure zone for sea surface, entrained or dissolved hydrocarbons was predicted with the NT/WA coastline or adjacent islands. Contact was not predicted with the Tiwi Islands as the regional ocean currents in the Timor Sea – the ITF and Holloway Current (**Figure 5-4**) – direct ocean waters in a prevailing north-east/south-west direction. Refer to **Appendix L** for further detail on the ocean currents in the area.

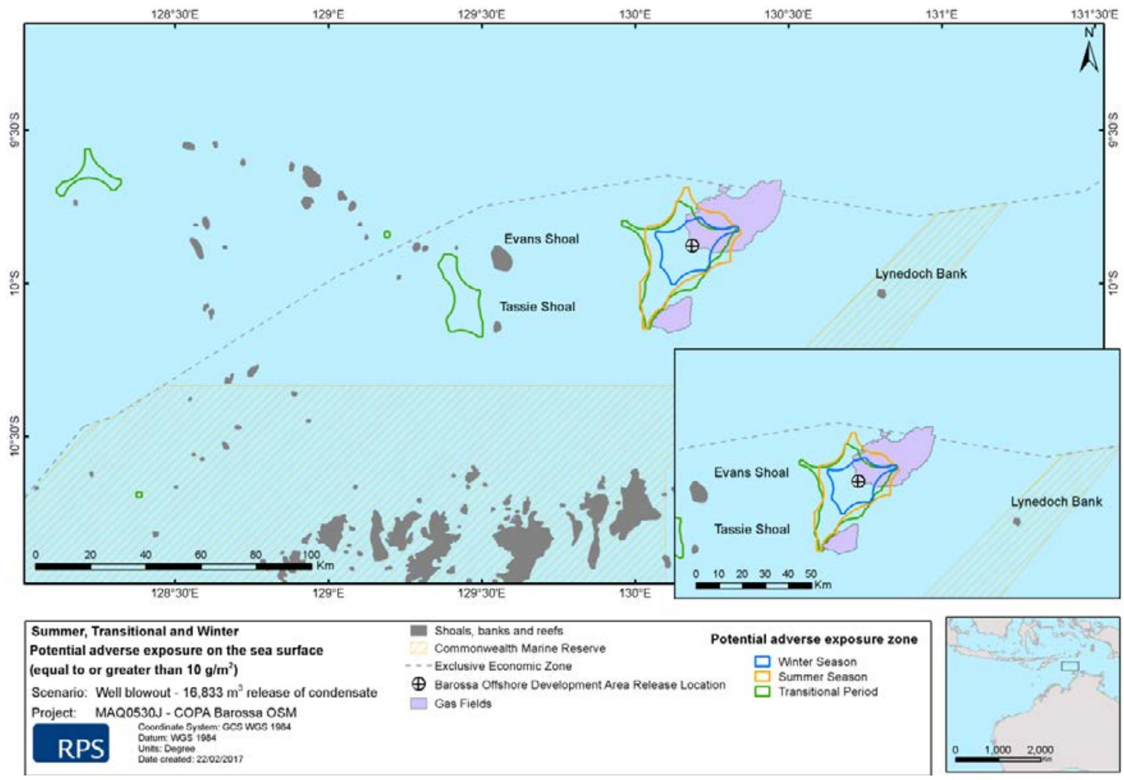


Figure 6-24: Stochastic modelling outputs showing the potential adverse exposure zone on the sea surface from a long-term well blowout

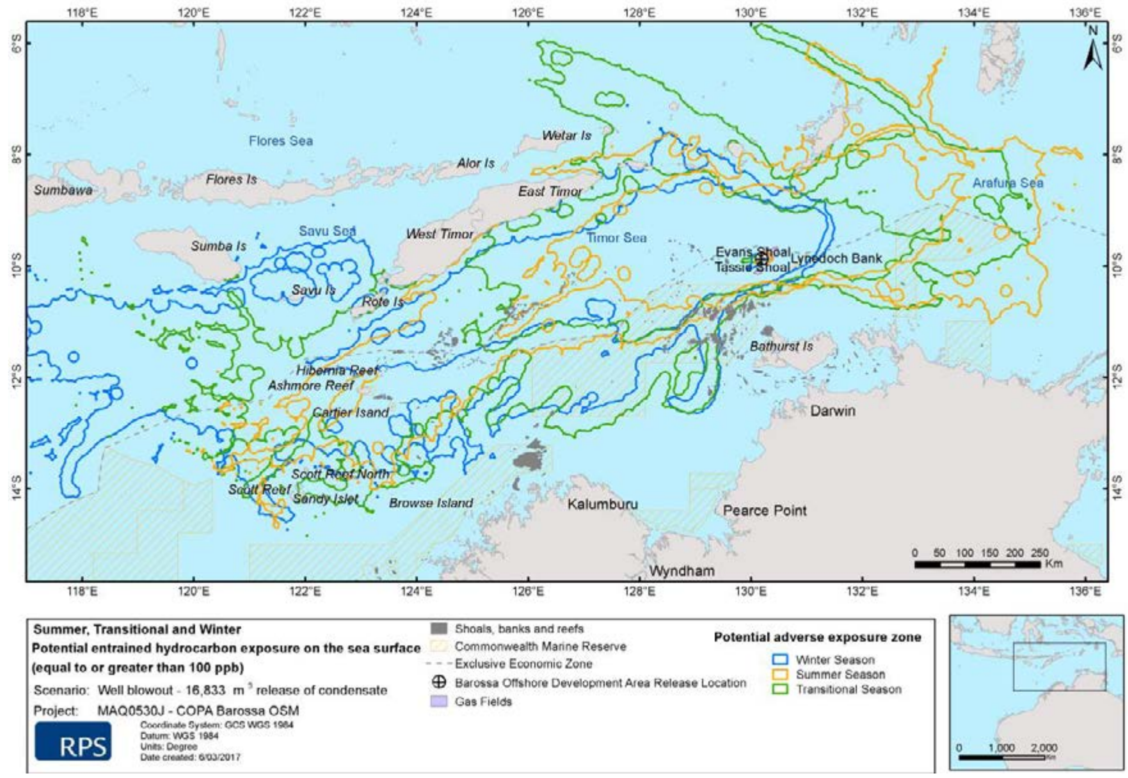


Figure 6-25: Stochastic modelling outputs showing the potential adverse exposure zone (0-10 m depth layer) for entrained hydrocarbons from a long-term well blowout

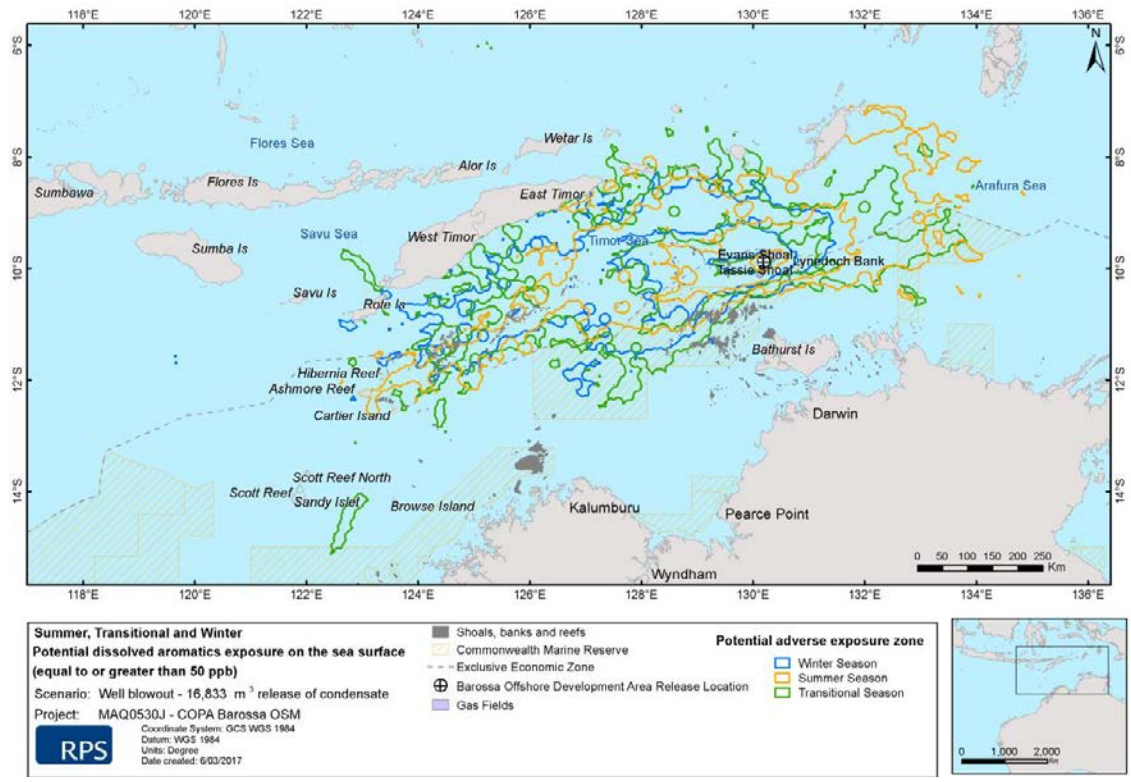


Figure 6-26: Stochastic modelling outputs showing the potential adverse exposure zone (0-10 m depth layer) for dissolved aromatic hydrocarbons from a long-term well blowout

6.4.10.10 Scenario 5: Vessel collision leading to loss of an offtake tanker fuel tank (650 m³ HFO)

In summary, the stochastic modelling results showed:

- The maximum distance from the source of the sea surface adverse exposure zone is predicted to vary between seasons with approximately 393 km, 277 km and 805 km during summer, transitional and winter conditions, respectively.
- Contact was predicted (1–17% probability) by sea surface films within the adverse exposure zone to surface waters above a number of submerged shoals/banks (total of 13), KEFs of the carbonate bank and terrace system of Van Diemen Rise, tributary canyons of the Arafura Depression and the open waters of the Oceanic Shoals and Arafura AMPs, depending on the season (**Figure 6-27**).
- Contact by the sea surface adverse exposure zone with the waters above the KEF of the shelf break and slope of the Arafura Shelf (a unique seafloor feature) and open waters of the Timor Reef Fishery was predicted in all seasons as the Barossa development area is located within the bounds of these features.
- No entrained or dissolved aromatic hydrocarbon exposure is predicted at any threshold in any season and, therefore, no contact with submerged or in-water values/sensitivities is expected through this exposure pathway.
- No shoreline contact was predicted within the adverse exposure zone during any season.

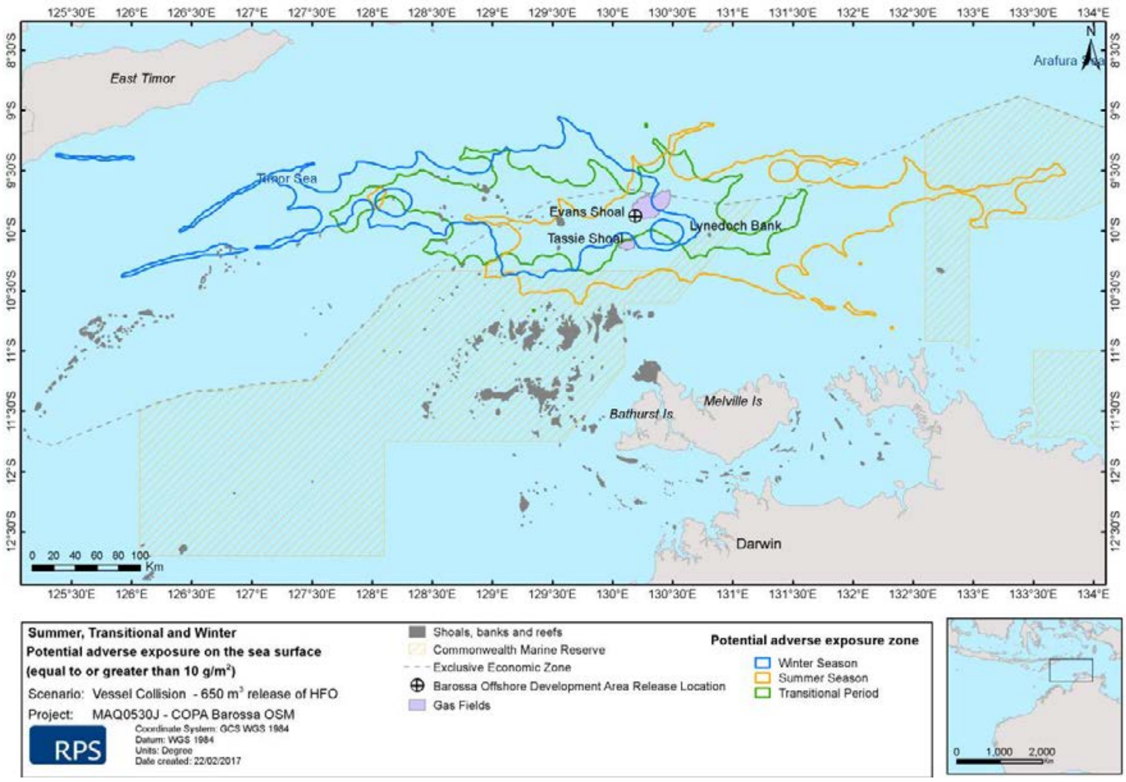


Figure 6-27: Stochastic modelling outputs showing the potential adverse exposure zone on the sea surface from an offtake tanker vessel collision releasing HFO

6.4.10.11 Scenario 6: Vessel collision leading to loss of a single pipelay vessel fuel tank (500 m³ IFO-180)

In summary, the stochastic modelling results showed:

- The maximum distance from the source of the sea surface adverse exposure zone is predicted to vary between seasons at approximately 136 km, 120 km and 395 km during summer, transitional and winter conditions, respectively.
- A low probability of contact is predicted (1–16%) by sea surface films within the adverse exposure zone with the surface waters above submerged shoals/banks and reefs (0-10 m), and KEF of the carbonate bank and terrace system of Van Diemen Rise (40–70% probability), and the open waters of the Oceanic Shoals marine park, depending on the season (**Figure 6-28**).
- Contact is predicted (1–34% probability) by sea surface films within the adverse exposure zone with Bathurst Island, Melville Island and the Darwin coastline in the summer and transitional seasons only.
- No entrained or dissolved aromatic hydrocarbon exposure is predicted at any threshold in any season and, therefore, no contact with submerged or in-water values/sensitivities is expected through this exposure pathway.

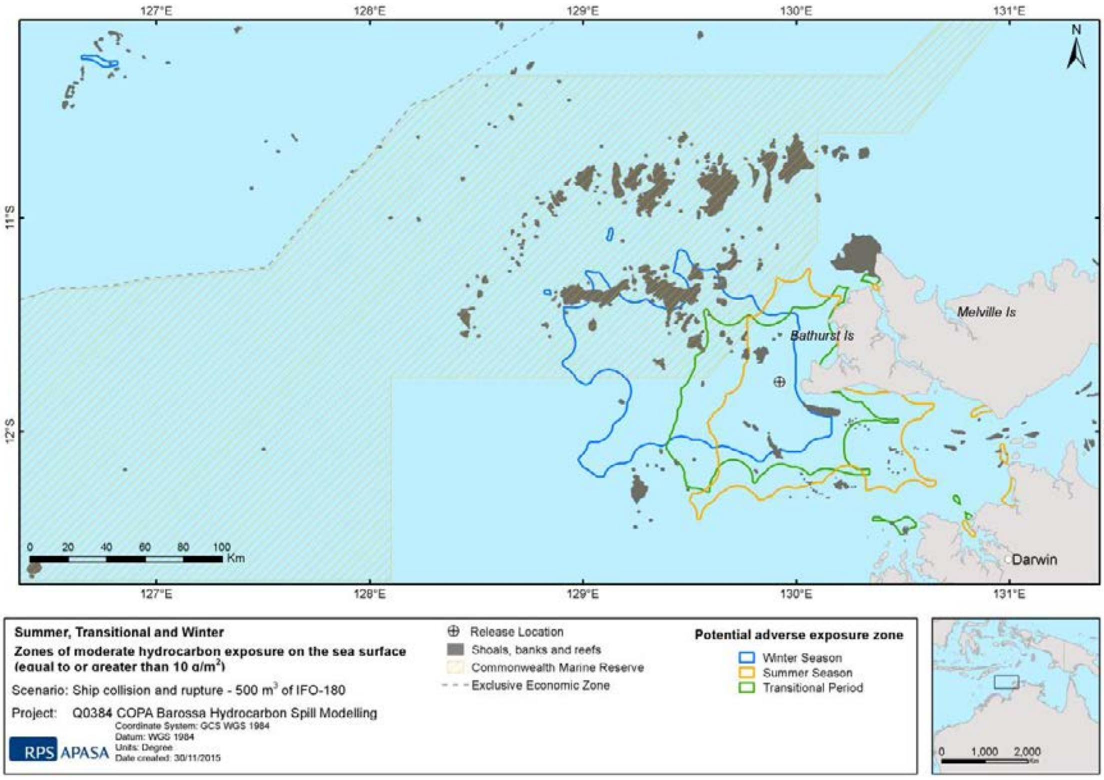


Figure 6-28: Stochastic modelling outputs showing the potential adverse exposure zone on the sea surface from a pipelay vessel collision releasing IFO-180

6.4.10.12 Impact assessment and risk evaluation

Table 6-46 presents a summary of the key environmental, socio-economic and cultural features that may be contacted by the adverse exposure zone (i.e. exposed to surface, entrained and dissolved hydrocarbons at or above moderate threshold concentrations), as predicted by the stochastic modelling (RPS 2017e). All of the features listed in **Table 6-46** occur within the broader area of influence for the project.

Table 6-46: Summary of predicted hydrocarbon contact for the maximum credible spill scenarios

Key environmental, socio-economic and cultural features		Hydrocarbon contact with the adverse exposure zone in the area of influence (maximum credible spill scenario)		
		Sea surface hydrocarbon film	Entrained hydrocarbons	Dissolved aromatic hydrocarbons
Physical environment	Commonwealth waters – water quality	✓ (all scenarios)	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)
	Indonesian, Timor and Timor-Leste waters – water quality	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)	✓ (Scenario 3, 4)
Biological environment	Shoals and banks (e.g. Evans Shoal, Tassie Shoal, Lyndoch Bank, Goodrich Bank, Marie Shoal, Shepparton Shoal)	✓ (waters above) (Scenario 2, 3, 4, 5, 6)	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)
	Tiwi Islands	✓ (Scenario 6)	No contact predicted	No contact predicted
	Other offshore reefs and islands (i.e. Ashmore Reef, Cartier Island, Hibernia Reef, Seringapatam Reef, Scott Reef)	No contact predicted	✓ (Scenario 2, 3, 4)	✓ (Scenario 4)
	NT/WA mainland coastline	✓ (Scenario 5 – Darwin coast only)	No contact predicted	No contact predicted
	Indonesian and Timor-Leste coastline	No contact predicted	✓ (Scenario 2, 3, 4)	✓ (Scenario 3, 4)
	Marine fauna: marine mammals, marine reptiles (turtles and sea snakes), birds (seabirds and migratory shorebirds), fish and sharks and rays*	✓ (all scenarios)	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)
	Plankton	✓ (all scenarios)	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)
Socio-economic and cultural environment	Oceanic Shoals marine park	✓ (Scenario 2, 3, 5, 6)	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)
	Arafura marine park	✓ (Scenario 5)	✓ (Scenario 2, 3, 4)	✓ (Scenario 3, 4)
	Arnhem marine park	No contact predicted	✓ (Scenario 4)	No contact predicted
	Kimberley marine park	No contact predicted	✓ (Scenario 4)	✓ (Scenario 4)
	KEF – shelf break and slope of the Arafura Shelf	✓ (waters above) (Scenario 1, 2, 3, 4, 5)	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)
	KEF – carbonate bank and terrace system of the Van Diemen Rise	✓ (waters above) (Scenario 2, 3, 4, 5, 6)	✓ (Scenario 2, 3, 4)	✓ (Scenario 2, 3, 4)
	KEF – pinnacles of the Bonaparte Basin	✓ (waters above) (Scenario 3)	✓ (Scenario 2)	✓ (Scenario 4)

Key environmental, socio-economic and cultural features	Hydrocarbon contact with the adverse exposure zone in the area of influence (maximum credible spill scenario)		
	Sea surface hydrocarbon film	Entrained hydrocarbons	Dissolved aromatic hydrocarbons
KEF – tributary canyons of the Arafura depression	✓ (waters above) (Scenario 5)	✓ (Scenario 2, 3)	✓ (Scenario 4)
KEF – carbonate bank and terrace system of the Sahul Shelf	No contact predicted	✓ (Scenario 2)	✓ (Scenario 4)
KEF – continental slope demersal fish communities	No contact predicted	✓ (Scenario 4)	✓ (Scenario 4)
KEF – ancient coastline at 125 m depth contour	No contact predicted	✓ (Scenario 4)	✓ (Scenario 4)
Ashmore Reef – marine park, KEF, Commonwealth Heritage place and Ramsar wetland	No contact predicted	✓ (Scenario 2, 3, 4)	✓ (Scenario 4)
Cartier Island – marine park and KEF	No contact predicted	✓ (Scenario 2, 3, 4)	No contact predicted
Seringapatam Reef – KEF and Commonwealth Heritage place	No contact predicted	✓ (Scenario 4)	No contact predicted
Scott Reef – Commonwealth Heritage place	No contact predicted	✓ (Scenario 4)	No contact predicted
Marine archaeology	✓ (waters above) (Scenario 6)	No contact predicted	No contact predicted
Commercial fishing	✓ (all scenarios)	✓ (Scenario 2, 3, 4, 5)	✓ (Scenario 2, 3, 4, 5)
Recreational fishing – in the vicinity of the Barossa offshore development area	✓ (waters above) (Scenario 2, 3, 4, 6)	✓ (Scenario 2, 3, 4, 5)	✓ (Scenario 2, 3, 4, 5)
Recreational and traditional fishing – in the vicinity of the Tiwi Islands	✓ (Scenario 6)	No contact predicted	No contact predicted
Tourism, recreational and scientific research	✓ (Scenario 6)	No contact predicted	No contact predicted
Commercial shipping	✓ (Scenario 2, 3, 4, 5, 6)	✓ (Scenario 2, 3, 4)	✓ (Scenario 3, 4)
Offshore petroleum exploration and operations	✓ (Scenario 6)	✓ (Scenario 2, 3, 4)	✓ (Scenario 3, 4)
Defence activities (NAXA)	✓ (Scenario 2, 3, 5)	✓ (Scenario 2, 3, 4)	✓ (Scenario 3, 4)

* Includes consideration of BIAs associated with marine fauna and habitat critical to the survival of flatback and olive ridley turtles (**Section 5.6**).

Scenario 1: Refuelling incident (10 m^3 marine diesel).
Scenario 2: Vessel collision leading to loss of a single FPSO facility fuel tank (2,975 m^3 marine diesel).
Scenario 3: Vessel collision leading to loss of a single FPSO facility condensate storage tank (19,400 m^3 Barossa condensate).
Scenario 4: Long-term well blowout (16,833 m^3 Barossa condensate).
Scenario 5: Vessel collision leading to loss of an export tanker fuel tank (650 m^3 HFO).
Scenario 6: Vessel collision leading to loss of a single pipelay vessel fuel tank (500 m^3 IFO-180).

Based on the key environmental, socio-economic and cultural factors that may be affected by a hydrocarbon spill as summarised in **Table 6-46**, the broad values/sensitivities at risk may include:

- benthic communities and habitats, particularly those associated with shoals, banks, offshore reefs and islands
- Tiwi Islands (coastline)
- NT and WA mainland (coastline)
- marine fauna (marine mammals, marine reptiles, seabirds and migratory shorebirds, fish and sharks/rays, including species of conservation significance)
- plankton
- AMPs
- KEFs
- marine archaeology
- commercial, recreational and traditional fishing
- tourism, recreation and scientific research
- commercial shipping
- offshore petroleum exploration and operations
- defence activities (NAXA)
- Indonesian and Timor-Leste (coastline).

Overall, potential impacts from hydrocarbons released into the marine environment are influenced by the characteristics of the hydrocarbon, the location of the hydrocarbon in the water column (i.e. sea surface, entrained and/or dissolved aromatics) and the degree of weathering. The discussion below outlines the main impacts that may be experienced as a result of an unlikely hydrocarbon spill.

It should be noted that this assessment conservatively assumes no spill response arrangements are deployed. In reality, a comprehensive management and monitoring framework would be implemented in rapid response to the unplanned scenarios presented in this OPP. Refer to **Section 7** for an outline of ConocoPhillips emergency preparedness and response framework.

Benthic communities and habitats (including those associated with shoals/banks, offshore reefs and islands)

Benthic communities, such as macrofauna and infauna (e.g. filter feeders, brittle stars, crustaceans, polychaete and molluscs) and BPPH (e.g. macroalgae, seagrass and corals), are vulnerable to hydrocarbons (surface, entrained and dissolved). Lethal and/or sub-lethal effects include mortality and changes in population recruitment, growth and reproduction leading to changes in community composition and structure (Wei et al. 2012). Filter feeders are particularly susceptible as they are likely to directly ingest hydrocarbons while feeding. This may cause mortality or sub-lethal impacts such as alteration in respiration rates, decreases in filter feeding activity and reduced growth rates, biochemical effects (Keesing and Edgar 2016).

The impact of hydrocarbons on macroalgae and seagrass varies depending on the type of hydrocarbon, degree of contact and species morphology, which influences the amount of hydrocarbon that may adhere to the algae/seagrass. Potential impacts may include smothering or coating (intertidal areas, and more commonly associated with IFO-180/HFO as the hydrocarbon does not intend to entrain but becomes semi-solid to solid), reduced photosynthesis (due to direct contact or through absorption of the water soluble fraction, which is most commonly associated with marine diesel and condensate spills as they entrain within the water column) and a reduction in tolerance to other stress factors (Runcie et al. 2004; Taylor and Rasheed 2011).

Seagrass in the intertidal zone, such as that of the Tiwi Islands, is particularly susceptible if surface hydrocarbons associated with more persistent hydrocarbons types (e.g. IFO-180) come into contact with the seagrass. The surface oil has the potential to become stranded on the seagrass and smother it during the rise and fall of the tide, resulting in reduced growth rates, blackened leaves and mortality (Howard et al. 1989, cited in Runcie et al. 2004). Studies have shown that impacts on algae and seagrasses are variable; however, they do not appear to be significantly affected by hydrocarbon spills and generally recover quickly (Runcie et al. 2004; Taylor and Rasheed 2011). A study by Wilson and Ralph (2010) concluded that long-term impacts to seagrass are unlikely unless hydrocarbons are retained within the seagrass meadow for a prolonged duration, which is more likely to be associated with the release of persistent hydrocarbons (IFO-180/HFO).

Benthic communities in the Barossa offshore development area may be affected by hydrocarbons released from a subsea well blowout. Based on the plume dynamics of the scenario modelled, a study investigating the impacts to deep, soft-bottom benthic invertebrates from the Macondo spill in the Gulf of Mexico observed that within 3 km of the release location benthic communities exhibited a significant reduction in faunal abundance and diversity (Montagna et al. 2013). Evidence of these impacts became less conclusive with increasing distance from the release location, with no detectable impacts recorded > 15 km from the well blowout (Montagna et al. 2013). It is important to note that the impacts associated with a subsea well blowout in the Barossa offshore development area is a different context, considering the differences in hydrocarbon type (Barossa condensate versus Macondo light crude, which is a 'heavier' and more persistent hydrocarbon than the Barossa condensate) and sub-surface plume trajectories (**Section 6.4.10.4**). Nonetheless, the findings from the Macondo spill may provide a broad indication of the likely nature and scale of potential impacts.

There are no significant benthic communities in the Barossa offshore development area (Jacobs 2016c). Macrofauna in the Barossa offshore development area were recorded in low numbers and were dominated by common species with infauna communities characterised by low abundance and species diversity of burrowing taxa and demersal fish. In general, the deep water benthic characteristics were broadly consistent with those observed in the broader NMR and support widespread macrofauna and infauna species. Given the low sensitivity and widely represented nature of the benthic communities in the Barossa offshore development area, the ecological consequence of potential impacts are considered minor.

Studies and field observations have shown that coral species are susceptible, at varying degrees, to hydrocarbons (e.g. marine diesel, condensate, HFO and IFO-180) and display a range of effects including mortality, decreases in coral reproduction (i.e. reduction in coral fertility), inhibited growth rates, reduced colonisation capacity; and feeding and behavioural responses (Shigenaka 2001; National Oceanic and Atmospheric Administration (NOAA) 2010a). Specific stress responses observed have included excessive mucous production, polyp retraction, changes in calcification rates, changes in primary production rates, bleaching (loss of zooxanthellae) and muscle atrophy (NOAA 2010a). It is thought that many of the sub-lethal effects are the result of affected corals trading off normal physiological functions (e.g. reproduction and growth) for exposure related responses, such as cleaning and damaged tissue regeneration (Shigenaka 2001). This reallocation of energy ultimately reduces the fitness of the affected corals, therefore making them more susceptible to mortality and natural stressors. The mortality of a number of coral species may result in the reduction of coral cover and longer term effects on the coral community structure and habitat. For example, branching corals (e.g. Acropora species) appear to be more sensitive to oil coating and retention when compared with massive corals (Shigenaka 2001).

The location of the coral community in the water column may influence the level and type of hydrocarbon exposure. In general, shallow water communities (< 20 m–30 m) are more likely to be at risk of being contacted by hydrocarbons than those in deeper waters, based on the nature of most hydrocarbons and considering that most hydrocarbon spill scenarios that may occur during the project are surface releases. Corals present on reef flats are more likely to be directly contacted by surface hydrocarbons while sub-tidal corals may be exposed to entrained and dissolved aromatic hydrocarbons, which are more likely to be associated with marine diesel and condensate spills.

Impacts to coral communities have the potential to be more pronounced if the hydrocarbon spill occurs during a coral spawning event as the early life stages of corals may be more sensitive than adult colonies (Negri and Heyward 2000). Coral gametes and larvae are susceptible to surface hydrocarbons as they display a tendency to float in or remain near the upper water column, where they may be contacted by the WAF (Villanueva et al. 2008). Hydrocarbons may also cause the premature release of underdeveloped larvae, reduce survivorship, reduced rates of fertilisation, metamorphosis and inhibit settlement of larvae, and decrease growth rates (Goodbody-Gringley 2013; van Dam 2011; Villanueva et al. 2008).

Studies have reported that the dispersed oil (i.e. combination of hydrocarbons and chemical dispersants) is significantly more toxic to larvae than the WAF (Goodbody-Gringley 2013; Lane and Harrison 2000). A study of broadcast scleractinian coral larval observed that the lifespan of the larvae varied substantially between species, with median lifespans (50% mortality) of 4–138 days and maximum longevity ranging from 23 days to 244 days (Graham et al. 2008). However, it was also noted that, despite the long lifespans, the species exhibited high mortality rates in approximately the first two weeks and then again after 100 days, when energy reserves reached critically low levels (Graham et al. 2008). Woodside (2014) suggests that the vulnerability of coral planktonic stages to surface hydrocarbons would be largely confined to up to three weeks after spawning events. However, potential impacts to coral larvae may extend beyond this period if contacted by entrained or dissolved hydrocarbons.

Based on the maximum credible spill scenarios and the predicted adverse exposure zone from stochastic modelling, contact with benthic communities and habitats associated with shoals/banks, offshore reefs and islands, may occur. While the nearest shoals/banks are predicted to be contacted in some seasons by entrained and dissolved hydrocarbons within approximately 1–4 days (Scenarios 2, 3 and 4), the majority of the shoals/banks have a long time to contact (ranging between > 4 days and 68 days, depending on the spill scenario and season), with the reefs and islands of Ashmore, Cartier, Hibernia, Seringapatam and Scott having a contact time of between 15 days and 72 days. In the unlikely event of a significant hydrocarbon spill in the Barossa offshore development area, potential impacts to these communities/habitats from the released hydrocarbons is not expected to be significant (i.e. cause large-scale death of corals and affect coral populations) in most cases when considering the times to contact and taking into account the hydrocarbon characteristics and weathering/decay of the entrained and dissolved hydrocarbons (**Section 6.4.10.4**). For example, Barossa condensate has very low levels of aromatics in the three ring PAHs and above in the low volatility fraction, meaning that the weathered residues of the condensate are not considered to present ecotoxological threat in the water column (RPS 2017e).

The review of the regional shoals and banks undertaken by AIMS (Heyward et al. 2017; **Appendix F**) demonstrated that benthic communities in the Barossa offshore development area show strong similarity with neighbouring shoals and banks (i.e. within 100s of km's), frequently sharing approximately > 80% of benthic community composition (Heyward et al. 2017) (refer **Section 5.5.3**). Variability in benthic communities observed between individual shoals/banks, e.g. relative abundance of common taxa, in many cases has been attributed to dynamic response to differing cycles of disturbance history such as storms/cyclones or thermal stress events (**Appendix F**). AIMS concluded that there is an extensive series of "stepping stone" habitats available to recruit larvae and connect these ecosystems at ecological time scales. As relevant to this aspect, it is noted that these findings demonstrate a strong level of regional connectivity across the shoals and banks in the area of influence. Connectivity between shoals and banks across the bioregion is considered to be high, with nearest neighbour shoals/banks likely to act as source reefs for shoals/banks downstream. Therefore, in the unlikely event of a significant hydrocarbon release affecting a shoal or bank, potential impacts would be similar and given the interconnectivity, an impact on a single feature does not necessarily translate into significant ecological loss at a regional scale.

Contact by dissolved and entrained condensate at moderate or high exposure thresholds (**Section 6.4.10.3**) at the shoals/banks within a short time period (approximately < 1 day) will likely have lethal and sub-lethal impacts to those benthic communities contacted. However, as the hydrocarbon concentration decreases and weathers, the communities are expected to recover. Woodside (2014) noted that should coral communities at Scott Reef, which is located within the (previously) proposed Browse FLNG Development Area, be affected by a large-scale hydrocarbon release of Browse condensate, the communities would take from less than a decade to up to several decades or longer to recover. Corals affected at the shoals/banks in the vicinity of the hydrocarbon release would be expected to exhibit similar recovery timeframes. The likelihood of such impacts occurring is assessed as low, given a large-scale release is considered very unlikely due to the key management controls that will be implemented throughout the life of the project.

Potential impacts to the benthic communities of the Tiwi Islands and any shoals/banks of the Van Diemen Gulf which extend into the upper water column (0 m–10 m) from a large-scale hydrocarbon release at the southern end of the gas export pipeline (i.e. Scenario 6) are likely to be greater than spills originating in the Barossa offshore development area or northern end of the pipeline given their proximity to the pipeline and the characteristics of the hydrocarbon that may be released (i.e. IFO-180; **Section 6.4.10.4**). Impacts associated with IFO-180 are likely to be associated with smothering or coating as the hydrocarbon is not expected to dissolve or entrain in the water column. Benthic communities that come into contact with the hydrocarbon for an extended period of time (i.e. stranded oil) are expected to experience some mortality and sub-lethal effects. However, significant loss of benthic communities at the Tiwi Islands is not expected as the only portions of the waters around the islands are predicted to be affected by the large-scale release at the southern end of the pipeline (**Figure 6-28**). Considering the key management controls that will be implemented over the life of the project, that will be subject to further assessment and demonstration of ALARP and acceptable controls as part of the activity-specific EP, this scenario of a large-scale release is highly unlikely to occur during installation of the gas export pipeline.

Tiwi Islands coastline

The adverse exposure zone associated with a pipelay vessel collision at the southern end of the gas export pipeline route (Scenario 6 – release of IFO-180) has the potential to contact the shorelines of the Tiwi Islands. IFO/HFO typically contains mainly persistent hydrocarbons (**Section 6.4.10.4**) that have the potential to cause damage in the shoreline habitats through smothering.

The Tiwi Islands support a number of shoreline habitats, including extensive stands of mangroves, tidal mudflats, sandy beaches, seagrass meadows and fringing reef habitats (INPEX 2010). Mangroves are vulnerable to surface, entrained and dissolved hydrocarbons. The physical smothering of aerial roots by surface and stranded hydrocarbons (e.g. IFO-180/HFO) can block the trees' breathing pores used for oxygen intake and result in the asphyxiation of sub-surface roots (International Petroleum Industry Environmental Conservation Association (IPIECA) 1993). The lower molecular weight aromatic hydrocarbons (more commonly associated with marine diesel or condensate) can damage root cell membranes and interfere with the trees' salt exclusion process (IPIECA 1993). These physical and toxic effects can lead to reduced survival and growth rates, reduced seedling recruitment, mangrove dieback (e.g. canopy loss) or mortality (Duke and Burns 2003). Hydrocarbons trapped in mangrove habitats can persist and remain toxic for extended periods of time as the anaerobic nature of sediments slows biodegradation of the hydrocarbons and allows aromatic components to persist (Duke and Burns 2003). Mangrove habitats are also a low energy environment and the likelihood of stranded hydrocarbons being removed by wave action is low.

Observations of offshore hydrocarbon spill events have shown that oil spills can result in persistent or permanent loss of mangrove habitat. As a representative example, post-spill monitoring of mangroves affected by a crude oil spill (which has a high percentage of persistent hydrocarbons) in the Parramatta River (Sydney) showed a reduction in leaves and small branches three years after the incident (Holzheimer et al. 2010). The release of 14,000 barrels of bunker fuel (which is similar to HFO) off the coast of Panama resulted in the severe oiling of mangroves, causing deforestation (observed 5 years after the spill) and death of a large number of mangrove seedlings (with new recruits observed 11 years post-spill) (NOAA 2014). While mangroves may be affected by hydrocarbon spills, they have shown that they can also recover from these events over time. For example, mangroves at a site that became heavily defoliated following a spill of HFO off the coast of Trinidad showed extensive new growth on both oiled and unoiled trees approximately 6–12 months after the spill (Dahlin et al. 1994). There was some sign of chlorosis and no signs of oil on the roots. Close inspection of the formerly oiled fringing mangroves indicated these trees were healthy—fully foliated, with no signs of chlorosis (Dahlin et al. 1994). In other instances, small coastal spills in WA have been reported to have caused short-term (< 2 years) defoliation of small areas of mangroves (< 1 ha) (Duke and Burns 1999, cited in Holzheimer et al. 2010). In another example, the release of 450 tonnes of fuel oil from a bulk ore carrier in 1988 led to heavy oiling of mangroves at Cape Lambert (WA), however no deforestation or death of mangroves was observed (Duke & Burns 1999, cited in Holzheimer et al. 2010). These case examples show variability in response of mangrove environments to hydrocarbon spills, but with some capacity to recover over time.

Tidal mudflats, like mangroves, are a low energy environment and are, therefore, susceptible to potential impacts from persistent surface or stranded hydrocarbons. Hydrocarbons in contaminated sediments can persist for years and result in significant impacts, particularly on benthic infauna, and their dependent migratory shorebird populations (Duke and Burns 2003). Saenger (1994) noted that mudflats were the most severely affected habitat two years after the Gulf War spill, with no sign of living epibiota.

Persistent hydrocarbons (e.g. IFO-180/HFO) that become stranded on sandy beaches are likely to persist for extended periods and become buried into the sediments. Fernandez-Fernandez et al. (2011) studied the long-term persistence of HFO (similar general characteristics to IFO in terms of a high persistent fraction) in sandy beaches on the coast of Spain, for seven years following the Prestige oil spill. The study recorded that low concentrations of HFO were buried within the sand as tar balls or oil coatings (last step of physico-chemical degradation) seven years after the spill.

The potential impacts to the benthic communities of seagrass meadows and fringing reefs habitats are considered above. The Tiwi Island coastline also supports important nesting sites for marine turtles, significant seabird rookeries, and some major aggregations of migratory shorebirds (DLRM 2009). The potential impact to these marine fauna groups are discussed in detail in the following sub-section below.

In summary, hydrocarbons released from a pipelay vessel collision at the southern end of the gas export pipeline route have the potential to contact the shorelines of the Tiwi Islands at concentrations which could result in adverse impacts to shoreline habitats and marine fauna, without the implementation of appropriate management controls or spill response strategies. Potential impacts could include long term damage and/or contamination of shoreline habitats, mortality of individual adult turtles or hatchlings or mortality of individual seabirds/shorebirds if they come into contact with oiled sections of the shoreline. Only a portion of the shoreline habitat is expected to be affected and therefore impacts at regional benthic community distribution or population level are considered unlikely. As the hydrocarbon disperses over time the shoreline habitats are expected to recover. While this assessment is conservative, the application of key management controls for the prevention, planning and response framework to mitigate the risk of such a release will be implemented to demonstrate ALARP and acceptable outcomes through the activity-specific EP. Refer to the discussion below for further detail on the potential impacts to marine fauna from surface or stranded hydrocarbons.

NT and WA mainland coastline

The Darwin coastline supports a diverse range of habitats including mangroves, intertidal flats, shoals, rocky shores and pavements, sand beaches and mud flats. The coastline also provides habitat for protected marine fauna species including seabirds and migratory shorebirds, turtles, sea snakes, dugongs, dolphins, fish, sharks and rays.

The nearshore and coastal environments of the Kimberley support a diverse array of marine habitats and communities including coral reefs, sandy beaches, rocky shores, seagrass meadows, mangroves, sponge gardens, wetlands and estuaries (DEC 2009). These communities provide important habitat for a number of marine fauna, including specially protected and culturally and commercially important species such as marine turtles, cetaceans, dugongs, fish, prawns and birds (DEC 2009).

Based on the maximum credible spill scenarios and the predicted adverse exposure zone from stochastic modelling, some impact to the NT mainland coastline may occur. As the modelling did not predict contact with the WA coastline from a large-scale release originating in the project area, potential impacts to the WA coastline are not expected. However, in the unlikely event that contact does occur, impacts are not expected to be significant considering the long time to contact and taking into account the hydrocarbon characteristics and weathering/decay of the released hydrocarbons (**Section 6.4.10.4**).

In the unlikely event of a vessel collision in the southern end of the gas export pipeline, some areas of the Darwin coastline may be affected. While the probability of contact is very low (1–2%), the time to contact is in the order of 5–6 hours. Based on the characteristics of IFO-180 (**Section 6.4.10.4**), some smothering of benthic communities and marine fauna may occur. The potential impacts to these values/sensitivities are discussed both above and below.

Marine fauna

Marine mammals

As identified in the EPBC Protected Matters search and Barossa marine studies program, a number of whale and dolphin species and the dugong may occur or have habitat in the project area (refer **Section 5.6**). Marine mammals are highly mobile with various studies suggesting they are able to detect and actively avoid contact with surface hydrocarbons (Smith et al. 1983; Geraci and St. Aubin 1988; Woodside 2011). For example, pods of tucuxi (an estuarine/river dolphin) were reported to have immediately left Guanabara Bay (Rio de Janeiro) for the open coastline following a large spill of bunker fuel and were observed to return to feeding habitats within the bay once these habitats were free from oil (Kirwan and Short 2003). However, other observations have noted that marine mammals have swum directly into areas affected by hydrocarbons without appearing to detect or actively avoid the area (Volkman et al. 1994; Woodside 2011; NOAA 2017). For example, there is evidence from recent spill events, such as Macondo, to suggest that marine mammals such as the common bottle nose dolphin in the vicinity were significantly affected from contact with crude oil and therefore do not always exhibit avoidance behaviours (Balmer et al. 2015; Lane et al. 2015; Schwackeet al. 2013).

Marine mammals that come into direct physical contact with surface, entrained or dissolved hydrocarbons may become coated, ingest or inhale the hydrocarbons. The direct physical coating of marine mammals (which is more likely to occur with more persistent hydrocarbons such as HFO and IFO- 180) is expected to be relatively minor given whales, dolphins and dugongs are generally smooth skinned with limited areas of hair (Woodside 2011). The skin of marine mammals also generally consists of a thick epidermal layer which acts as a barrier to any potential toxic effects associated with hydrocarbons (Volkman et al. 1994; Englehardt 1983).

The ingestion (direct or through consumption of prey) or inhalation of hydrocarbons may cause irritation of sensitive membranes (e.g. eyes, mouth, digestive and respiratory tracts, and organs), burns to mucous membranes, impairment of the immune system or neurological damage (Etkins 1997; IPIECA 2004). Baleen whales, such as pygmy blue, Bryde's whales and humpbacks, may have an increased risk of ingesting contaminated foods based on their preference for feeding at/near the sea surface. However, their main food source (zooplankton) is able to rapidly process hydrocarbons and regenerate, with oil particles incorporated into faecal pellets (Pidcock et al. 2003; Varela et al. 2006). Therefore, the greatest risk is likely to be associated with feeding directly in or around a fresh hydrocarbon spill (Pidcock et al. 2003). Studies on the impacts of hydrocarbons on the feeding ability of baleen whales also showed that feeding efficiency was only temporarily reduced (Pidcock et al. 2003).

Dugongs could be indirectly affected if the released hydrocarbons cause the dieback of seagrass. Therefore, the availability of feeding areas may be reduced if hydrocarbons smother or coat subtidal and intertidal seagrass. Based on modelling of the pipelay vessel collision, hydrocarbons, in particular the persistent fraction of IFO/HFO, have the potential to smother a portion of the intertidal feeding areas in the vicinity of the Tiwi Islands and Darwin Harbour, to a lesser extent. Impacts at a population level are considered highly unlikely as the spill is not expected to result in the loss of entire seagrass meadows, with any affected seagrass likely to recover. Population impacts are also not anticipated as the spill will not encompass the entire range over which dugongs have been recorded or impact the significant dugong and seagrass sites on the north-west of Melville Island (**Figure 5-17**).

The adverse exposure zone associated with some of the maximum credible spill scenarios (Scenarios 2 to 5) originating from the Barossa offshore development area are predicted to encompass a small portion of the biologically important foraging and migration areas (Commonwealth waters) for pygmy blue whales and open waters of the humpback whale calving/resting/nursing and migration area. In Scenarios 2 to 4, the hydrocarbon will spread and evaporate rapidly on the sea surface or become entrained/dissolved in the upper water column (0 m–10 m) but will not persist in the environment given the characteristics of marine diesel and Barossa condensate (**Section 6.4.10.4**). While HFOs (Scenario 5) are typically highly persistent and may smother individuals if they come into direct contact with the hydrocarbon on the sea surface while transiting the area. Toxic effects are less likely as HFOs have low solubility and low bioavailability (RPS 2017e; ITOPF 2011). Migrations of both pygmy blue whales and humpback whales extend over several months and encompass a large geographical area. Feeding during these migrations is generally low level and opportunistic and, as such, the opportunity for ingestion of hydrocarbons is reduced. Therefore, the whole population of the species is unlikely to be within the adverse exposure zone and, as such, a hydrocarbon spill associated with the project is not expected to affect an entire population or the overall viability of the population.

The adverse exposure zone associated with a pipelay vessel collision at the southern end of the gas export pipeline route (Scenario 6) has potential to encompass a small portion of the biologically important breeding, calving and foraging area for the Indo-pacific humpback dolphin in the vicinity of Darwin Harbour. Considering the wide distribution of the species along the northern Australian coastline, and that individuals have been observed to migrate between sites along the NT coastline (**Section 5.6.6.2**), potential impacts are likely to be limited to a number of individuals as compared to a population level.

Marine reptiles

Adult marine turtles do not appear to exhibit avoidance behaviour on encountering hydrocarbon spills (Odell and MacMurray 1986). Contact with hydrocarbons can result in coating of body surfaces causing irritation of mucous membranes in the nose, throat and eyes which can then cause inflammation and infection (Gagnon and Rawson 2010, NOAA 2010b). Potential impacts to the respiratory and digestive systems may also result from inhalation of toxic vapours when they come to the surface to breathe or through ingestion of hydrocarbons. Respiratory impacts are likely to be more commonly associated with marine diesel and condensate as they have a high proportion of volatiles (**Section 6.4.10.4**). However, given the volatile nature of these hydrocarbons, the hydrocarbon on the sea surface is expected to evaporate rapidly (in the order of approximately 60–79% of the hydrocarbon over the first two days) and therefore the potential for respiratory impacts is relatively temporary. The predicted adverse exposure zone from the maximum credible spill scenarios of marine diesel and condensate (Scenarios 2 to 4) also does not intersect the entire internesting habitat critical to the survival of flatback and olive ridley turtles. Considering the large area utilised by internesting flatback (approximately 32,478 km^2) and olive ridley turtles (approximately 7,791 km^2) in the vicinity of the Tiwi Islands, and that they generally do not feed during internesting but rest on the seabed, the potential for impacts at a population level are unlikely considering the fate and weathering of the hydrocarbons.

While little is known about the sensitivity of sea snakes to hydrocarbons, impacts from direct contact with surface hydrocarbons are likely to be similar to those experienced by marine turtles, such as potential skin damage and irritation of mucous membranes of the eyes, nose and throat. They may also be impacted when coming to the sea surface to breathe through the inhalation of the toxic vapours associated with the hydrocarbons, thereby causing damage to the respiratory system. While there is no information available in relation to impacts on saltwater crocodiles, potential effects to crocodile eggs are expected to be similar to turtles (Oates 2016a).

The adverse exposure zone associated with some of the maximum credible spill scenarios from the Barossa offshore development area has potential to influence various BIAs/habitat critical to the survival of turtles, in particular the internesting areas for flatback turtles and foraging areas for flatback, green, olive ridley and loggerhead turtles. There are no BIAs for sea snakes within the adverse exposure zone, however, they are generally associated with coral reefs in an offshore context. While individual turtles and sea snakes may be affected in the event of a hydrocarbon spill as they transit the Barossa offshore development area, impacts at a regional scale and population level are considered unlikely considering the lack of, or low likelihood of, hydrocarbons contacting shorelines, the long time to contact with the BIAs/habitat critical to the survival of turtles and taking into account the weathering/decay of the hydrocarbon released (**Section 6.4.10.4**).

The entrained and dissolved adverse exposure zone associated with some of the maximum credible spill scenarios (Scenarios 2 to 4) from the Barossa offshore development area has the potential to contact a portion of the waters directly adjacent to the biologically important nesting areas for green turtles at Ashmore Reef and Cartier Island (**Figure 5-18**) at low probabilities (1–5%). Given the long time to contact with the nesting BIAs, and considering the weathering/decay of the hydrocarbon released (**Section 6.4.10.4**), significant impacts to nesting beaches, and turtle populations utilising these beaches, are not expected.

A pipelay vessel collision at the southern end of the gas export pipeline route (Scenario 6) may lead to a greater impact to marine turtles given its relatively close proximity to the Tiwi Islands, which are an important nesting and internesting area. Potential impacts would be greatest during the peak internesting season for flatback and olive ridley turtles (between June and September for flatback turtles and April to August for olive ridley turtles) (**Section 5.6.3.2**). However, population level impacts are considered unlikely as the hydrocarbons are not predicted to contact the entire nesting and internesting habitats critical to the survival of these species. Additionally, the number of female turtles nesting have been observed to vary markedly between years and can be attributed to environmental conditions and food availability (DoEE 2017a). Individual females also generally do not breed each year. For example, flatback turtles have been observed to breed at intervals between one to five years (mean of 2.7 years) (DoEE 2017e). Olive ridley turtles, however, differ to the other marine turtle species in that the majority (over 60%) of females nest every year (IUCN 2017). Taking this into account, and that contact is not predicted with the entire nesting/internesting habitat critical to the survival of these species, the likelihood of population level impacts is considered remote.

The area of influence associated with a pipelay vessel collision (Scenario 6) is predicted to contact portions of the Tiwi Island shorelines which support turtle nesting. Adult and juvenile turtles may be exposed to hydrocarbons on shorelines (e.g. HFO or IFO-180 emulsions) when they come ashore seasonally to nest or when internesting in the surrounding waters (**Table 5-12**). Any stranded hydrocarbon interacting with the coastal fringes of the Tiwi Islands is likely to represent the persistent fraction in the form of viscous liquid in the earlier stages and as tar balls as the hydrocarbon weathers. Adult and juvenile turtles may become coated in the hydrocarbon as they move to/from shore and may also ingest surface oil as they pass through the affected area. While turtle eggs are unlikely to be exposed to beached hydrocarbons, as most turtles nest well above the high-tide level, they may be directly exposed through the transfer of hydrocarbons from the oiled female turtle (Shigenaka 2003). The degree of weathering of the hydrocarbon influences the potential impact of egg viability; weathered hydrocarbons having little impact while fresh hydrocarbons may have a significant impact on success rate (Milton et al. 2002).

In summary, considering the project location and existing environment context, no population level impacts are expected to marine reptiles as a result of unplanned hydrocarbon releases. Individuals may be affected as they move through the area of influence with impacts dependent on the nature and scale of a potential release. The implementation of key management controls for the prevention, planning and response framework will further mitigate the risk of such a release and will be defined in detail in the activity-specific EP.

Seabirds and migratory shorebirds

Birds may be exposed to hydrocarbon spills through several pathways, primarily immersion, ingestion and inhalation. The adherence of hydrocarbons to feathers can cause them to matt, lose their insulation (and, therefore, lead to hypothermia), buoyancy or water repellent characteristics, which may result in the inability to fly or feed and lead to drowning (IPIECA 2004). Physical contact with hydrocarbons may also result in anaemia, pneumonia and irritation of eyes, skin, nasal cavities and mouths (IPIECA 2004) and result in mortality from the ingestion of hydrocarbons via preening or contaminated food. Ingestion of hydrocarbons can result in sub-lethal effects including internal organ damage, decline in immune system, reduced reproduction capability, reduction in number of eggs and egg fertility, and disruption of normal breeding and incubating behaviours (AMSA 2016). Exposure can also occur through inhalation of volatile fumes, causing damage to the lungs, pneumonia and neurological impairments such as ataxia (IPIECA 2004). As outlined above, respiratory impacts are likely to be more commonly associated with releases of marine diesel and condensate. However, given the volatile nature of these hydrocarbons, the potential for respiratory impacts is relatively temporary as the majority of the spill is predicted to evaporate in the first few days.

It has been noted that seabirds do not appear to exhibit avoidance behaviour to surface hydrocarbons and therefore may come into contact with the spill while feeding or resting on the sea surface.

Shorebirds are generally not as susceptible to direct oiling when compared to seabirds; however, they can be affected indirectly through impacts on their feeding/foraging and breeding habitat. In terms of nesting, oil can be transferred from the parent's feathers to the young or eggs (ITOPF 2011). Contamination of the eggs by hydrocarbons can result in eggshell thinning, failure of the egg to hatch and development abnormalities (ITOPF 2011).

The adverse exposure zone associated with some of the maximum credible spill scenarios (Scenarios 2 and 4) is predicted to influence a number of biologically important breeding and foraging areas in the vicinity of Ashmore Reef and Cartier Island for seabirds, at very low probabilities. Individuals utilising the area may be affected if they come into direct contact with the sea surface adverse exposure zone (> 10 g/m^2). However, considering the low density of seabirds and migratory shorebirds in the open waters of the area and significant distance to key seabird roosting/nesting sites, and taking into account the nature and weathering of the hydrocarbons (**Section 6.4.10.4**), impacts at a population level are considered unlikely. No shorelines of significant importance for seabird breeding or aggregation are predicted to be contacted by the surface adverse exposure zone for any of the maximum credible spill scenarios modelled in the Barossa offshore development area. It was reported from wildlife response operations implemented as a result of the Montara well blowout incident that 27 birds in the Timor Sea region were affected by the spill, with 17 of these dying as a result of being oiled (Short 2011).

The adverse exposure zone associated with the maximum credible spill scenario of a pipelay vessel collision at the southern end of the pipeline (Scenario 6) has potential to influence the Tiwi Islands coastline and nearshore waters, mainly to the south and west of Bathurst Island. Therefore, the persistent fraction from an IFO/HFO spill may affect portions of the breeding/nesting and resting sites for a large number of seabirds and shorebirds on the Tiwi Islands. In particular, there is the potential to contact a portion of the BIA for a large breeding colony of crested terns, which includes a 20 km foraging buffer extending off the northern tip of Melville Island. Potential impacts are likely to be greatest during the nesting period between April and July (**Table 5-12**). Birds that come into direct contact with the adverse exposure zone may be subject to smothering (i.e. oiling of plumage) as well as lethal or sub-lethal toxic impacts through ingestion of the hydrocarbon from preening of feathers. Contact with weathered IFO/HFO may also cause irritation or ulceration of the eyes, skin, mouth or nasal cavities (AMSA 2016).

The long-term effects of large-scale hydrocarbon spill on seabirds and shorebirds have been reported as variable. Some reports state that biological systems are inherently variable such that the effects of oil mortality are statistically undetectable and therefore relatively insignificant (Wiens 1995, cited in Oates 2016b). Other studies have reported that large unplanned spills can potentially deplete bird populations and cause desertion of single seabird colonies, although resilience of seabird populations to these single catastrophic events has generally been observed (Oates 2016b). Seabird populations can recover from large-scale spills through a number of mechanisms. For example, species with long life spans and high survival rates contain a substantial number of non-breeders in the population that may buffer the loss of reproductive adults, while other species have a higher reproductive potential such that adult losses can be more rapidly replaced (Oates 2016b). Other long-term studies have indicated that seabird populations affected by significant spills (e.g. Prestige oil spill in the North Atlantic) have not recovered to pre-spill levels 8–10 years after the spill occurred. However, it is acknowledged that predicting population recovery times is difficult as the effects of oil pollution cannot always be differentiated from natural environmental variation and population dynamics (Oates 2016b).

Considering the modelling outcomes and the existing environment context, significant impacts to bird populations are unlikely to occur as a result of unplanned hydrocarbon releases. A number of individuals may be affected if they come into the contact with the area of influence, with impacts dependent on the nature and scale of a potential release. However, key management controls will be implemented throughout the life of the project to mitigate the risk of a large-scale release occurring.

Fish

Pelagic fish generally do not experience acute mortality from hydrocarbon spills as they are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas (Scholz et al. 1992). Demersal fish are highly unlikely to be impacted by surface spills as they generally inhabit waters near the seabed. However, they may be impacted in the event of subsea well blowout if they are in close proximity (< 1 km) to the release location and come into contact with the hydrocarbons either directly or indirectly (e.g. through ingestion in-water or via consumption of prey). Contamination of the seabed in the vicinity of the release location may also result in localised impacts to demersal fish habitat and therefore result in displacement of populations from the area.

Contact with surface hydrocarbons and direct coating/smothering can lead to acute physical effects in fishes which cause changes in olfactory senses or vision, skin lesions, tainting of flesh, changes in feeding or mortality (Davies et al. 1993, Carls et al. 1996, Marty et al. 1999, cited in Westera and Babcock 2016). Chronic effects associated with the toxic components in the water soluble fraction (i.e. entrained and dissolved component of marine diesel and condensate) of the hydrocarbon can include growth inhibition, inhibited swimming ability, reduced reproductive success, immune system responses, deformities and visible skin and organ lesions (Westera and Babcock 2016).

Mass fish mortalities associated with hydrocarbon spills are rare, with those mortalities that have occurred being associated with very high, localised concentrations of dispersed oil in the water column (ITOPF 2011). Fish have an increased susceptibility to hydrocarbons during their early life stages (eggs, larvae and juveniles) with potential impacts from low concentrations of PAHs including reduced survival rates due to sub-lethal effects, developmental defects of the skeletal system and disruption of cardiac function (Incardona et al. 2004).

Studies on the toxicological and physiological effects of the Montara well blowout incident involved assessment of effects of the hydrocarbon on fishes (including biopsies of fish tissue samples and olfactory analysis of fish fillets) through sampling within a week of the control of the hydrocarbon release and repeated sampling for two years thereafter. Four fish species were sampled and comprised two demersal species (goldband snapper and red emperor) and two pelagic species (Spanish mackerel and rainbow runner). The study reported that, in the short term, fishes were exposed to, and metabolised, petroleum hydrocarbons but there were few broad scale negative effects (Westera and Babcock 2016). Two years after the incident, biomarker levels in goldband snapper and red emperor had generally returned to reference levels, except for liver size, which was larger in fishes collected close to the Montara well location (within 50 km) (Westera and Babcock 2016). However, this was potentially attributed to local nutrient enrichment, or to past exposure to petroleum hydrocarbons.

The area of influence associated with the large-scale credible scenarios affect open ocean waters which support a number of fish species (**Section 5.6.5**). Individuals that come into contact with the hydrocarbon as they traverse through the area may experience acute or chronic effects. However, impacts at a population level are considered unlikely given the vast habitat through which fish species move through. Entrained and dissolved condensate is unlikely to cause significant toxicity effects as the low volatility fraction of the hydrocarbon contains very low levels of aromatics, which have the greatest potential to cause toxicity effects (**Section 6.4.10.4**).

Whale sharks may be at risk of exposure to hydrocarbons through ingestion, either directly while feeding at/near the sea surface or indirectly through contaminated prey. As with cetaceans, ingestion of hydrocarbons may lead to contamination of tissues and internal organs, reduced function of the immune system, irritation of sensitive membranes (e.g. eyes, mouth, digestive and respiratory tracts and organs) or possibly poisoning resulting in mortality. Stochastic modelling for Scenarios 2 to 4 shows that the adverse exposure zone extends to the northern section of the foraging BIA for whale sharks, at very low probabilities. Therefore, while individual whale sharks that have direct contact with hydrocarbons may be affected, significant impacts to migratory whale shark populations are not expected as the species is highly migratory and forages over a broad geographical area.

Sharks and rays

Sharks, rays and sawfish may be affected by hydrocarbons as a result of direct contact or through contamination of tissues and internal organs (including via the food chain through consumption of prey). As with fish, it is likely that pelagic species are able to detect and avoid surface expressions of a hydrocarbon spill by swimming into deeper water or away from the affected areas. Individuals that come into contact with hydrocarbons in the water column may experience irritations of sensitive membranes (e.g. eyes, mouth, digestive and respiratory tracts and organs) or possibly poisoning through ingestion of prey.

The open offshore waters within the adverse exposure zone do not contain known significant breeding and feeding habitats for large numbers of sharks, rays and sawfish to be exposed to hydrocarbons in the unlikely event of a maximum credible spill scenario being realised from the Barossa offshore development area. Considering this, and that there are no BIAs in the adverse exposure zone, it is expected that any potential impacts to sharks, rays and sawfish would be limited to transient individuals that may be passing through the area of influence. No threat to the overall population viability is anticipated.

The adverse exposure zone associated with the maximum credible spill scenario of a pipelay vessel collision at the southern end of the pipeline (Scenario 6) is predicted to affect waters in close proximity to the Tiwi Islands and Darwin coastline. Coastal and estuarine waters provide suitable habitat for the speartooth shark, northern shark and sawfish (green, largetooth and dwarf). Individuals of these species that come into contact with the adverse exposure zone may be subject to lethal or sub-lethal impacts. While individuals may be affected, population impacts are not anticipated as the spill will not encompass the entire range of these species.

Plankton

Plankton communities are not considered to be highly sensitive to disturbance as they are variable in space and time and undergo regular recruitment (American Petroleum Institute (API) 2001). In general, surface hydrocarbon spills that do not entrain or dissolve in the water column have a reduced impact on plankton as only a small proportion of the community is close to the surface and therefore susceptible to exposure from hydrocarbons (API 2001).

The main pathways for direct exposure and contamination of plankton are ingestion, absorption and adherence of hydrocarbons to the external body wall or gills. The short regeneration time of plankton (9–12 hours) and rapid replacement of stocks from adjacent areas due to water circulation will usually prevent any impact at the population or community level (Batten et al. 1998). However, this does depend upon the geographical scale of the spill and plankton distribution within the area. Indirect impacts include smothering, ingestion of contaminated food, changes to behaviour, loss of recruitment, and changes to trophic dynamics that impact productivity. Derivatives of hydrocarbons have been observed to decrease feeding and growth rates of copepods (Hjorth and Nielsen 2011).

A study investigating the effects of PAHs on mesozooplankton following the Macondo spill in the Gulf of Mexico observed impacts to the species extended for a period of up to two months after the well blowout ceased (Mitra et al. 2012). As the average life expectancy of mesozooplankton in the Gulf of Mexico is approximately seven days, Mitra et al. (2012) suggested that PAHs were accumulating in the species and being transferred to future generations via their lipid rich eggs. Therefore, exposure of plankton to hydrocarbons has the potential to result in lagging impacts through the means of bioaccumulation, as they are the base of the food chain. The study also revealed that the exposure of mesozooplankton was patchy, with communities close to the well location appearing unaffected by PAHs while individuals up to 180 km away showed signs of being exposed (Mitra et al. 2012).

Considering the spatial and temporal variation of phytoplankton and zooplankton communities within marine waters, significant impacts to plankton communities are unlikely.

Australian Marine Parks

Stochastic modelling results indicate that a number of AMPs may be affected by the adverse exposure zone for sea surface, entrained and dissolved aromatic hydrocarbons should a maximum credible spill scenario occur (**Table 6-40**).

Potential impacts to the key values and sensitivities that may occur within the AMPs, such as marine fauna, offshore reefs and islands, shoals and banks are discussed in detail above.

Key ecological features

Potential impacts to the key values and sensitivities, such as benthic habitats/communities (e.g. macrofauna, infauna, macroalgae, seagrass) and marine fauna (e.g. whales, dolphins, turtles, sea snakes, seabirds, migratory shorebirds, fish, sharks and rays), that are associated with the KEFs of Ashmore Reef, Cartier Island and Seringapatam Reef and Commonwealth waters in the Scott Reef complex, are discussed in detail above.

The open waters above the seabed KEFs of the shelf break and slope of the Arafura Shelf, carbonate bank and terrace system of the Van Diemen Rise, pinnacles of the Bonaparte Basin, tributary canyons of the Arafura depression, carbonate bank and terrace system of the Sahul Shelf and ancient coastline at 125 m depth contour may be contacted by the adverse exposure zone. Impacts to these seabed KEFs are considered to be minimal given their location on the seabed and the surface nature of the majority of the spills (e.g. vessel collisions), and the behaviour of the Barossa condensate plume from a subsea well blowout, in which the concentration of the entrained and dissolved hydrocarbons is highest in the upper water column (RPS 2017e). As the plume from the subsea well blowout will rise rapidly to the surface water layer (0 m–10 m) within a short distance from the release location (**Section 6.4.10.4**) the likelihood of direct contact at these features with the released hydrocarbons is reduced. The KEFs of the tributary canyons of the Arafura depression and carbonate bank and terrace system of the Sahul Shelf are also significantly distant from the Barossa offshore development area (> 240 km) and therefore, taking into account the nature and weathering of the marine diesel and condensate hydrocarbons (**Section 6.4.10.4**), significant impacts to these features are considered unlikely.

While the seabed in the immediate vicinity of the well blowout location may be affected (within approximately 100 m) (as discussed in 'Benthic communities and habitats' above), impacts to the KEF of the shelf break and slope of the Arafura Shelf are considered highly unlikely as the previous seismic surveys acquired by ConocoPhillips in 2007 and 2016, recent geophysical surveys in 2015 and 2017, ROV footage collected during pre and post-spud surveys during exploration and appraisal drilling campaigns and from the extensive baseline studies undertaken across the area (refer **Section 5.2**) did not observe any of the sensitivities attributed to the KEF within the Barossa offshore development area (**Section 5.5.2.1**).

The KEF of the continental slope demersal fish communities has been identified as being contacted by the adverse exposure zone for entrained and dissolved hydrocarbons (Scenario 4 only). The potential impacts to fish from hydrocarbons are discussed above. Significant impacts to this KEF are considered unlikely considering the long time to contact (> 31 days) and weathering characteristics of the hydrocarbons (**Section 6.4.10.4**). The modelling also predicted a very low probability (1–2%) of contact with this KEF.

Marine archaeology

Stochastic modelling predicts that the sea surface adverse exposure zone associated with a significant hydrocarbon release at the southern end of the gas export pipeline (i.e. Scenario 6) extends over the waters of three historic shipwrecks (two steamer ships and a submarine) listed under the Commonwealth *Historic Shipwrecks Act 1976*. However, significant impact to these shipwrecks is considered highly unlikely given they are located in waters > 6 m in depth and a potential spill would be on the sea surface (i.e. IFO-180 does not entrain or dissolve in to the water column).

Commercial fishing

The predicted adverse exposure zone associated with some of the maximum credible spill scenarios has the potential to result in impacts to the area fished by a number of Commonwealth and NT/WA commercial fisheries (**Table 5-9**). These fisheries generally target demersal and pelagic finfish species, prawns and sharks.

Toxic impacts from entrained and dissolved hydrocarbons associated with more volatile hydrocarbons, such as condensate and marine diesel, are of primary concern to commercial fisheries. The extent of the area of influence for the entrained and dissolved component of condensate and marine diesel spills (particularly Scenarios 2 to 4) have the potential to interact with various commercial fisheries. No entrained and dissolved hydrocarbon exposure was predicted for the HFO/IFO-180 releases (Scenario 5 and 6, respectively). Discussion of potential acute and chronic impacts to fish is provided above.

Fish exposure to hydrocarbons can result in 'tainting' of their tissues (Upton 2011, Hofer 1998). Even low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. However, tainting is generally reversible, although it is influenced by level of hydrocarbon contamination. Adult fish exposed to low entrained hydrocarbon thresholds are likely to metabolise the hydrocarbons and excrete the derivatives with studies showing that fish have the ability to metabolise petroleum hydrocarbons, although it is dependent upon the magnitude of the hydrocarbon contamination (Eisler 1987). In general, fish are not expected to retain a taint for longer than a week post-exposure to entrained or dissolved hydrocarbons (Gagnon and Holdway 2000, cited in Westera and Babcock 2016). In addition, the risks of tainting from oil discharges are usually low or localised (Davies et al. 1993, Hofer 1998, cited in Westera and Babcock 2016). Testing for tainting of fish flesh was undertaken following the Montara well blowout and reported no differences between impacted and non-impacted sites (Westera and Babcock 2016). It has been noted that crustaceans (e.g. prawns) have a reduced ability to metabolise these hydrocarbons (NOAA 2002).

Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishing, and can impact seafood markets long after any actual risk to seafood from a spill has subsided (NOAA 2002). A major spill would result in the establishment of a safety exclusion zone around the area affected by the spill and a temporary prohibition on fishing activities implemented for a period of time. The extent of the exclusion zone would be dependent on the nature and scale of the spill and would remain in place until it was deemed safe. This may be in the order of a number of days in the event of a large spill from a vessel collision or up to several months in the event of a long-term well blowout. Therefore, there is potential for subsequent direct short to medium term economic impacts to affected commercial fishing operators, with the nature and scale of these impacts dependent on the characteristics of the spill.

As outlined in **Section 6.4.10.4**, the entrained and dissolved component of the Barossa condensate is unlikely to cause significant toxicity effects as the low volatility fraction of the hydrocarbon contains very low levels of aromatics, which have the greatest potential to cause toxicity effects. Considering this, and the nature and scale of the large-scale releases, it is recognised that individual fish may be affected by hydrocarbons. However, long-term population impacts are not expected. The likelihood of such a large-scale release is also inherently low given the key management controls that will be implemented throughout the life of the project.

Recreational and traditional fishing

As outlined in **Section 5.7.14**. a number of fishing charters operate in the coastal waters along the NT coastline and in the vicinity of the Tiwi Islands. Consultation undertaken by ConocoPhillips has also identified one fishing charter operator who conducts tours in the vicinity of Evans Shoal and Goodrich Bank during the main fishing season (September to December). In the unlikely event that a large-scale hydrocarbon spill occurs in the Barossa offshore development area, impacts to these activities may occur. Recreational and traditional fishing activities in the vicinity of the Tiwi Islands may be impacted in the event of a large-scale release during the installation of the gas export pipeline, specifically at the southern end if an unplanned release occurred during the installation of the gas export pipeline (e.g. Scenario 6).

Refer to the discussion above for further detail on the potential impacts to fishing activities.

Tourism, recreation and scientific research

There is limited tourism and recreation in remote, offshore waters and on the Tiwi Islands. However, specimen shell collection occurs and diving charters operate in the vicinity of Ashmore Reef, Cartier Island, Hibernia Reef and Seringapatam Reef. Considering the location of the project and distance to these areas, large-scale spills in the Barossa offshore development area are highly unlikely to significantly affect these socio-economic activities. There may be an increased risk of affecting recreation and research activities should there be a large release in the vicinity of the Tiwi Islands (e.g. Scenario 6).

Commercial shipping

The main commercial shipping channel is approximately 90 km to the west of the Barossa offshore development area (**Figure 5-26**). Based on the stochastic modelling, the sea surface adverse exposure zone may extend into this commercial shipping channel in the highly unlikely event of a vessel collision (Scenarios 2 and 3) or long-term well blowout (Scenario 4) in the Barossa offshore development area. A pipelay vessel collision at the southern end of the gas export pipeline route (Scenario 6) may cause a greater impact to commercial shipping given its relative proximity to the Darwin Port.

Offshore petroleum exploration and operations

The stochastic modelling results show that other operator petroleum retention leases and exploration permit leases occur within the adverse exposure zone. However, as there are no operational production facilities and in-field subsea infrastructure within the immediate vicinity of the project, any exclusion zones that would be implemented in the unlikely event of a large-scale hydrocarbon release are unlikely to significantly affect other oil and gas operators.

Defence activities

The stochastic modelling results indicate that the open waters of the NAXA may be within the adverse exposure zone (sea surface, entrained or dissolved hydrocarbons). However, any potential exclusion zones that would be implemented in the unlikely event of a large-scale hydrocarbon release are considered unlikely to extend into the NAXA given it is relatively distant to the project area. ConocoPhillips would consult with the Department of Defence should a large hydrocarbon release occur and track towards the NAXA.

Indonesian and Timor-Leste

The coastlines of these countries support a range of habitats and communities, including sand and gravel beaches, rocky shores and cliffs, intertidal mud flats, mangroves, seagrass and coral reefs (Tomascik et al. 1997; Asian Development Bank 2014). The coastal waters provide habitat for a number of protected species, including humphead wrasses, marine turtles, giant clams, some mollusc species, crustaceans, cetaceans (dolphins and whales) and dugongs, and commercially important species of fish, shrimps and shellfish (Asian Development Bank 2014). The potential impacts to these shoreline habitats and marine fauna groups are considered in detail above.

Based on the maximum credible spill scenarios and the predicted adverse exposure zone (entrained and dissolved hydrocarbons only) from stochastic modelling, some impact to the coastlines may occur. However, should a large-scale hydrocarbon spill occur in the Barossa offshore development area, significant potential impacts to the coastlines are not expected given the relatively long time to contact (> 12 days) and taking into account the hydrocarbon characteristics and weathering/decay of the released hydrocarbons (**Section 6.4.10.4**).

ConocoPhillips has established communication lines with DFAT and would engage the agency if a hydrocarbon spill occurred and modelling predicted it would reach international waters/shorelines. ConocoPhillips also has offices in Indonesia, which would be engaged to provide local support in the event that a spill entered Indonesian waters.

6.4.10.13 Other unplanned discharges

Preliminary evaluation of subsea gas export pipeline release

While the evaluation of impacts and risks associated with the project is underpinned by the largest maximum credible scenarios (as presented in detail in **Section 6.4.10.6** to **Section 6.4.10.11**), a preliminary evaluation of a potential release of dry gas from the gas export pipeline has been considered. Given this represents a low probability scenario and the potential release of hydrocarbons is assessed and addressed in full in the maximum credible scenarios as described above, the following summary is provided for this early stage OPP assessment. It is important to note that the magnitude of any potential release from the gas export pipeline would be significantly smaller than the other maximum credible scenarios assessed. It is expected that with further pipeline engineering definition and design, a further assessment of this scenario would be provided as part of an activity-specific EP for the operational pipeline, once the details of design specifications and preventative integrity controls are known.

A preliminary analysis of potential subsea release scenarios from in-field subsea infrastructure was undertaken for the Barossa project by Intecsea (2017), as part of early concept engineering studies. The scenarios considered included a full bore rupture of a production riser and a release from the tie-in point with the gas export pipeline (i.e. PLET) in the Barossa offshore development area. Intecsea (2017) reported the maximum volume of hydrocarbon released from a full bore rupture of a production riser is limited to approximately 1 m3–6 m3 depending on whether a subsea isolation valve is fitted. No liquid hydrocarbons are expected to be released from the gas export pipeline scenario given the dry gas composition. Based on the composition of the Barossa condensate and the export gas specification for the project, the heavier hydrocarbon components (C5 or greater) are expected to account for less than 0.08mol% of the dehydrated gas composition within the export pipeline. Considering the very small to nil volumes of hydrocarbons that would be released from these subsea release scenarios, detailed spill modelling is not considered warranted for this minor volume of release. Furthermore, the release scenarios modelled in the Barossa offshore development area (Scenarios 1 to 5) are considered to represent a highly conservative estimate of the potential area that may be influenced by these subsea releases. Therefore, all potential impacts and risks associated have been assessed through consideration of the scenarios modelled and discussed in this OPP.

A release from the gas export pipeline will result in a plume of gas rising rapidly to the sea surface and forming a 'boil' area, in which the gas bubbles break through the surface (Intecsea 2017). In terms of the area that may be affected by a rupture of the gas export pipeline, it is not the volume of gas but rather the release rate and depth of a dry gas release that is important in determining the extent of a dry gas bubble or 'boil zone' and atmospheric gas plume (Holland 1997). Studies have concluded that the boil zone at the sea surface is approximately 20% of the water depth (Holland 1997; Intecsea 2017). Shell gives the range as 10–32% depending on release rate, based on observations such as the West Vanguard shallow gas blowout which occurred in 220 m water depth (Holland 1997). Assuming a full bore release of the gas export pipeline within the Barossa offshore development area in an average water depth of 240 m, and by applying the approach defined above, the boil zone at the sea surface would be approximately 48 square metres (m^2). A similar release in shallower water depths of the pipeline in Commonwealth waters (50 m) would result in a boil zone of approximately 10 m^2.

If the gas release rate is large enough, a flammable cloud is formed above the area of the release. The worst case flammable atmospheric plume associated with a full bore gas export pipeline release in water depths of 240 m and 50 m was calculated to extend up to approximately 1.7 km and 2.4 km (no wind), respectively, from the release location at 1 m above the sea surface (Intecsea 2017). These conditions were expected to occur for less than one day.

The predominant gas properties interacting with the environment during a gas release include methane gas, higher alkane gases (e.g. ethane, propane and butane), and small quantities of natural gas liquids and waxes. A study undertaken by Total and the U.K. authorities to characterise the effects of various gas properties from a gas leak at the Elgin Field (gas condensate reservoir) in the North Sea, concluded that the overall impact to the environment was negligible (Marine Scotland 2012). The gas that leaked dissipated naturally. Most of the condensate evaporated, while the remaining surface hydrocarbon sheen (<1/10th of a micron) also dispersed or evaporated in a few days, and any residue wax deposited within the immediate vicinity of the well causing contamination to a localised area. As a part of this study, Marine Scotland (2012) collected fish, water and sediment samples from the edge of a two-nautical mile (approximately 3.7 km) exclusion zone around Total's Elgin platform. While the study found traces of hydrocarbon contamination in sediment and seawater samples above background levels, the biomarker profiles were not consistent with those from the gas condensate. Therefore, the study concluded that there was no impact at this distance to sediment and seawater from the Elgin gas leak. Analyses of the 18 fish flesh samples collected confirmed there was no evidence of hydrocarbon contamination in any of the species analysed, and no taint was detected in any of the sampled fish species. Total confirmed that there had been no sightings of affected marine mammals or seabirds during the 32 aerial surveillance flights undertaken as part of the post-leak monitoring program (Marine Scotland 2012). The study concluded that there were no impacts to marine mammals at a population level given that there had been no impacts to fish (a lower order marine fauna species more susceptible to change than larger marine mammal species), no confirmed sightings to affected marine mammals, and that the area did not contain any important breeding, feeding or aggregation areas for marine mammals, and therefore only transitory individuals were likely to be present (Marine Scotland, 2012).

Potential environmental consequences arising from the ecotoxicological effects of gas releases from pipeline ruptures on marine biota, may result from the potential pathway of dissolution of gas in the water column. Exposure effects from gas on fish, for example, have been documented to be influenced by a range of factors (especially temperature and oxygen regime) which can significantly change the direction and symptoms of the effect (Patin 1999). In particular, increasing temperature may intensify the toxic effect of substances on fish due to the direct correlation between the level of fish metabolism and water temperature. Another environmental factor that directly influences the gas impact on water organisms is the concentration of dissolved oxygen. Numerous studies show that the oxygen deficit directly controls the rate of fish metabolism and decreases their resistance to many organic and inorganic compounds (Patin 1999).

Observations of fish response to the exposure of gas in the water agrees with the general pattern of typical response of organisms to any toxic or stress impact. This pattern involves consequent stages of indifference, stimulation (excitement), depression, and potential mortality (Patin 1999). The primary response to the gas presence has been observed to develop much faster than fish response to most other toxicants in the water. Clear signs of such response – increased motor activity – are observed within the first seconds after gas goes into the water. There may be a relatively short period between the first contact with gas and persistent signs of toxicological effect (latent phase). The duration of this phase in acute experiments is 15–20 minutes. The gas has potential to rapidly penetrate the bodies of fish, doing direct damage to gills, skin, chemoreceptors and eyes, and filling up the gas bladder, resulting in the fish being unable to control its buoyancy (Novaczek 2012).

Using fish as an indicator of biological response to gas releases in the water column, impacts to higher order marine fauna species, such as internesting turtles, may occur within the localized extent of the gas plume over a short duration given the rapid rise to the surface. However, impacts further afield from dissolved fractions are unlikely based on the outcomes previous studies described above (e.g. no taint detected in fish species approximately 3.7 km from the gas release location) (Marine Scotland 2012).

In the context of this project, it is reasonably assumed that the Barossa gas export pipeline will be constructed to a high standard of engineering specification. As noted previously in **Section 4.3.3.2**, it will be a 24–28 inch diameter carbon-steel pipeline with external anti-corrosion coating and anodes to maintain structural integrity, and a concrete coating to provide stability and mechanical protection. Given this, the inherent likelihood of a major gas release from the pipeline during operation is very low.

Oil and Gas UK had reported only 31 incidents involving loss of containment/leakage from operating steel and flexible pipelines in the North Sea up to 1991, mainly due to impact (e.g. vessels, trawling equipment), anchoring or corrosion (AME 1993). This finding is supported by other reviews (for example, Papadakis, 1999) that concluded that external interference, mostly third party activity involving interference using machinery, has been recognised as a dominant failure mechanism both in gas and oil industry pipelines. Taking into account the subsea installation of the proposed Barossa gas export pipeline, third party interference risks are limited in comparison to onshore facilities that may be subject to more frequent interactions.

Given the above findings, it is expected that any impacts from a pipeline rupture scenario would be localised and short term in nature. Dissolution effects of gas in the water column are expected to be localised to individual marine organisms that may be present in the vicinity of the potential leak location, in the vertical profile from the pipeline at seabed to the surface. This preliminary assessment has characterised the nature of the release to be a high velocity release of gas that will rise the surface within the localised boil zone. Therefore, the duration of exposure can be reasonably concluded to be short-term, however influenced by the nature and duration of release.

Considering the potential impacts to the marine environment from a full bore rupture of the gas export pipeline are very limited in terms of the boil zone (i.e. in the immediate vicinity of the rupture), and eco-toxicological effects, and the relatively localised and short term nature of the potential gas plume, all potential impacts and risks are considered to be addressed through the assessment of the maximum credible scenarios detailed in this OPP (i.e. they are within the area of influence) (**Table 6-44**). Given the controls that will be implemented for the project, including monitoring to assess structural integrity of the pipeline and for any potential leaks, the likelihood of the gas export pipeline rupturing is considered very remote and the consequence negligible. ConocoPhillips has been operating the Bayu-Undan to Darwin gas export pipeline without incident since 2006.

As described earlier, a further assessment of this risk of pipeline failure would be undertaken as part of an activity-specific EP for the operational pipeline, once the details of design specifications and preventative integrity controls are known.

Wet buckle during the gas export pipeline installation

One of the risks that exists during installation of the gas export pipeline is buckling. If a buckle occurs, it could result in rupture of the pipeline and seawater flooding the pipeline. This is referred to as 'wet buckle' and may occur anywhere along the gas export pipeline route between the Barossa offshore development area and the tie-in location with the existing Bayu-Undan to Darwin pipeline.

Should a wet buckle occur the seawater could lead to corrosion and reduced pipeline integrity if not removed. In the unlikely scenario that a wet buckle occurs the raw seawater would be displaced with chemically-treated seawater that may consist of biocides, corrosion inhibitor, scale inhibitor, dye and oxygen scavengers. The chemically-treated seawater would be separated from the raw seawater by bi-directional pig(s) pre-installed in the pipeline. The pipeline would then be dewatered either via the section where the wet buckle has occurred or through the entire gas export pipeline with compressed air depending on the location and extent of the buckle to enable pipelay to continue safely.

The volume of chemically-treated seawater that would be discharged in the event of a wet buckle depends on the location, extent and repair method. As a worst-case example, if installation of the pipeline was close to finishing, complete dewatering of the gas export pipeline and discharge of up to approximately 96,710 m^3 of chemically-treated seawater may be required to safely recover the pipeline and continue installation. Conversely, only the catenary length of the pipeline being recovered on board the pipelay vessel could be dewatered at this stage and the remaining volume of treated-seawater in the pipeline could be displaced during final re-flooding of the pipeline on completion of pipelay activities (e.g. during hydrotesting).

In the event wet buckling occurs during installation of the gas export pipeline, the maximum volume of discharge and the chemical characteristics of the filtered inhibited seawater flushed through the gas export pipeline and discharged are likely to be similar to that undertaken for dewatering. Therefore, the impacts and risks summarised for flooding fluid discharge are also applicable to wet buckling (**Section 6.4.8.6**). While the impact consequences described for dewatering are similar for wet buckling, the nature of this unplanned event means that there is a lower likelihood of wet buckling occurring during pipeline installation activities.

Impact and risk summary

The outer boundary of the worst case credible spill scenarios has the potential to result in a number of impacts including a reduction in water quality, direct toxic or physiological effects on marine biota such as corals and fauna of conservation significance including mammals, reptiles, birds, fish and sharks/rays, degradation of shoals/banks, reefs and islands, and socio-economic effects on commercial fishing, traditional fishing (Tiwi Islands) and tourism. Impacts from highly volatile hydrocarbons that have the potential to result in toxic effects to marine biota, such as condensate and marine diesel, are likely to be short in duration given the rapid evaporation experienced upon release. More persistent hydrocarbons such as HFO and IFO-180 are more likely to result in surface and smothering impacts. The predicted adverse exposure zone from a HFO release is limited to deeper offshore waters where there is limited sensitive benthic habitats prone to smothering effects and is not within any significant breeding or feeding areas for marine fauna. The adverse exposure zone from a release of IFO-180 may result in surface impacts (no impacts from dissolved and entrained hydrocarbons predicted) to contacted shorelines on the Tiwi Islands and smothering of key protected EPBC species where internesting habitat critical to the survival of flatback and olive ridley turtles and the crested tern BIA are present within the adverse exposure zone. While the potential consequence of the worst case credible spill scenario to local and regional sensitivities described above has been classified as significant, the likelihood of occurrence is remote and therefore, the residual risk of impact to the marine environment as a result of unplanned discharges associated with the project is considered moderate. The key management controls that will be implemented take into consideration the key values and sensitivities of the marine environment within the area of influence from a potential spill and are considered to manage potential impacts and risks to an acceptable level. A summary of the potential impacts, proposed key management controls, acceptability and EPOs for unplanned discharges are presented in **Table 6-46**.

The project is considered consistent with the relevant requirements of the Blue Whale Conservation Management Plan, Recovery Plan for Marine Turtles in Australia, Whale Shark Recovery Plan 2005-2010 and relevant marine fauna species conservation advices as related to unplanned discharges (**Table 6-47**). A summary of the potential impacts, proposed key management controls, acceptability and EPOs for unplanned discharges are presented in **Table 6-48**.

Table 6-47: Summary of alignment with relevant EPBC management plans for unplanned discharges

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)

Marine mammals - Blue whale	Blue Whale Conservation Management Plan (October 2015) (DoE 2015a)	Demonstrably minimise anthropogenic threats, including habitat modification through acute/chronic chemical discharge.	• The area of influence is predicted to encompass a small portion of the BIA for pygmy blue whales. Migrations of pygmy blue whales extend over several months and encompass a large geographical area. Therefore, a hydrocarbon spill associated with the project is not expected to affect the entire population or the overall viability of the population.
			• There are no BIAs for sei whales and fin whales in the area of influence.
			• A comprehensive suite of well-defined engineering controls will be implemented to minimise risks throughout the life of the development. All aspects of the project will be undertaken in accordance with the highest safety standard.
			• Core elements of the management framework to manage the risk of unplanned discharges include:
			  • maintenance of petroleum safety zones to minimise risk of collisions
			  • controls for hydrocarbon and chemical storage and bunkering
			  • comprehensive well design and control activities in accordance with approved regulatory requirements
			  • spill response preparedness and training, with Incident Management and Response planning, training and audits in place
			  • a comprehensive spill response strategy appropriate to the nature and scale of a potential release, supported by an OSMP.
			• No population level impacts are expected as a result of unplanned discharges, although individuals may be affected in the area of influence (as dependent on the nature and scale of the potential release).
			• Considering the remote likelihood of a large spill occurring and the management measures that will be implemented to minimise the risk of such an event occurring, the project is consistent with the management plan/conservation advices.

Marine mammals - Sei whale	Conservation advice (October 2015) (DoE 2015c)	Pollution (persistent toxic pollutants) has been identified as a threat to sei and fin whales. However, no specific actions or requirements have been defined.	
Marine mammals - Fin whale	Conservation advice (October 2015) (DoE 2015d)		

Marine reptiles - Loggerhead turtle Green turtle Leatherback turtle Hawksbill turtle Olive ridley turtle Flatback turtle	Recovery Plan for Marine Turtles in Australia 2017-2027 (June 2017) (DoEE 2017a)	Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival of the species.
		
		Manage anthropogenic activities in biologically important areas to ensure that biologically important behaviour can continue.
		
		Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs.
			• In the unlikely event that a large unplanned release occurs, the predicted adverse exposure zone from the maximum credible spill scenarios is not expected to affect the entire internesting BIAs or habitat critical to the survival for flatback and olive ridley turtles.
			• Although individuals may be affected in the area of influence, considering the large area utilised by internesting turtles (including internesting habitat critical to the survival and BIAs), the potential for impacts at a population level are unlikely.
			• A comprehensive suite of well-defined engineering controls will be implemented to minimise risks throughout the life of the development. All aspects of the project will be undertaken in accordance with the highest safety standard.
			• Core elements of the management framework to manage the risk of unplanned discharges include:
			  • maintenance of petroleum safety zones to minimise risk of collisions
			  • controls for hydrocarbon and chemical storage and bunkering
			  • comprehensive well design and control activities in accordance with approved regulatory requirements
			  • spill response preparedness and training, with Incident Management and Response planning, training and audits in place
			  • a comprehensive spill response strategy appropriate to the nature and scale of a potential release, supported by an OSMP. The OSMP will include individual operational and scientific monitoring plans for key values and sensitivities, such as turtles.

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Marine reptiles - Short-nosed sea snake[1] Leaf-scaled sea snake[1]	Conservation advice: short-nosed sea snake (December 2010) (DSEWPaC 2010a) and leaf-scaled sea snake (December 2010) (DSEWPaC 2010b)	Ensure there is no disturbance in areas where the species occurs, excluding necessary actions to manage the conservation of the species.	• A comprehensive range of key management controls will be implemented at all stages of the project to minimise the risk of unplanned discharges occurring. • An appropriate spill response framework will also be implemented in the unlikely event of a large release. • No population level impacts are expected as a result of unplanned discharges, although individuals may be affected in the area of influence (as dependent on the nature and scale of the potential release). • Considering the remote likelihood of a large spill occurring and the management measures that will be implemented to minimise the risk of such an event occurring, the project is consistent with the management plans/conservation advices. It is concluded that the implementation of management controls will allow the activities to be managed to ensure marine turtles are not displaced from identified habitat critical to their survival and that biologically important behaviour can continue.
Fish - Whale shark	Whale Shark Recovery Plan 2005-2010 (May 2005) (DEH 2005b) Conservation advice (October 2015) (DoE 2015i)	No specific actions or requirements are identified for managing pollution.	
Birds - Curlew sandpiper Eastern curlew	Conservation advice (May 2015) (DoE 2015e, f) (notes that the threats are particularly relevant to eastern and southern Australia)	No specific actions or requirements are identified for habitat loss and degradation from pollution for these species.	
Birds - Australian lesser noddy[1]	Conservation advice (October 2015) (DoE 2015g)		
Birds - Great knot[1]	Conservation advice (May 2016) (DoE 2016a)		
Birds - Greater sand plover[1]	Conservation advice (May 2016) (DoE 2016c)		
Birds - Lesser sand plover[1]	Conservation advice (May 2016) (DoE 2016c)		

Relevant factor	Relevant management plan/ recovery plan/conservation advice	Specific requirement(s) as relevant to the project	Demonstration of alignment (refer to the 'Impact assessment and risk evaluation' discussion above for further context)
Birds - Western Alaskan bar-tailed godwit[1]	Conservation advice (May 2016) (DoE 2016d)	Protect important habitat.	
Birds - Northern Siberian bar-tailed godwit[1]	Conservation advice (May 2016) (DoE 2016e)		
Birds - Red knot	Conservation advice (May 2016) (DoE 2016f)		
Sharks and rays - Great white shark	Recovery Plan for the White Shark *(Carcharodon carcharias)* (August 2013) (DSEWPaC 2013a)	No specific actions or requirements are identified for habitat modification/ degradation for these species from pollution as relevant to the project.	
Sharks and rays - Grey nurse shark	Recovery Plan for the Grey Nurse Shark *(Carcharias taurus)* (August 2014) (DoE 2014a)		
Sharks and rays - Speartooth shark Northern river shark Green sawfish Largetooth sawfish Dwarf sawfish	Sawfish and River Sharks Multispecies Recovery Plan (November 2015) (DoE 2015j) Conservation advice: speartooth shark (April 2014) (DoE 2014b), northern river shark (April 2014) (DoE 2014c), dwarf sawfish (October 2009) (DEWHA 2009) and green sawfish (2008) (DEWHA 2008b)	Reduce and, where possible, eliminate adverse impacts of habitat degradation and modification.	

[1] These species were identified only in the area of influence EPBC Protected Matters search.

Table 6-48: Summary of impact assessment, key management controls, acceptability and EPOs for unplanned discharges

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
Unplanned discharges	Physical environment – water quality, sediment quality. Shoals and banks. Tiwi Islands. Other offshore reefs and islands and NT/ WA mainland coastline. Marine mammals. Marine reptiles. Birds. Fish. Sharks and rays. Commercial fishing. Recreational and traditional fishing (Tiwi Islands).	Reduction in water quality. Direct toxic or physiological effects on marine biota, including corals, mammals, reptiles, birds, fish and sharks/rays. Hydrocarbon/ chemical contact with shoals/ banks, reefs and islands at concentrations that result in adverse impacts. Alteration of biological communities as a result of the effects on key marine biota. Socio-economic impacts on commercial fishing, traditional fishing (Tiwi Islands) and tourism.	*General* The OPGGS Act 2006 – Section 616 (2) Petroleum safety zones will be complied with, including establishment and maintenance of a petroleum safety zone around the well, offshore structure or equipment which prohibits vessels entering or being present within the specified area without written consent. Bunkering procedures will be implemented, which include: • use of bulk hoses that have dry break couplings, weak link break-away connections, vacuum breakers and floats • correct valve line-up • defined roles and responsibilities – bunkering to be undertaken by trained staff • visual inspection of hose prior to bunkering to confirm they are in good condition • testing emergency shutdown mechanism on the transfer pumps • assessment of weather/sea state • maintenance of radio contact with vessel during bunkering operations. Hydrocarbon and chemical storage and handling procedures appropriate to nature and scale of potential risk of accidental release will be implemented, which will include: • bulk hydrocarbons and chemicals stored in designated areas, with secondary containment • stocks of SOPEP spill response kits readily available onboard and personnel trained to use them • MSDS available on board for all hazardous substances.	The potential impacts and risks associated with unplanned discharges from the project are considered broadly acceptable given: • The residual risk is considered acceptable, as the proposed key management controls are considered good industry practice, take into consideration the key values and sensitivities of the marine environment within the area of influence from a potential spill and manage any potential additional impacts and risks which may be introduced as a result of the implementation of the mitigation measures (i.e. OPEPs and OSMP). • There is the potential for minor impacts to benthic communities located at Shepparton Shoal adjacent to the tie in location in the event wet buckling occurs in the immediate vicinity. However, the likelihood of wet buckling occurring within the immediate vicinity of the tie-in location is unlikely and the exposure timeframe associated with a wet buckling event at this location is relatively short duration. Further, given the ecological connectivity predicted amongst shoals in the region (Heyward et al. 2017) there are unlikely to be any unique features of significance at these locations, and as such impacts from wet buckling are expected to be minor.	Zero unplanned discharge of hydrocarbons or chemicals to the marine environment as a result of project activities. An activity-specific OPEP that demonstrates adequate arrangements for responding to and monitoring oil pollution, in the event of a major unplanned release, will be accepted by NOPSEMA prior to commencing the activity. An OSMP will be implemented in the event of a major unplanned release. The OSMP will include a number of operational monitoring plans and scientific monitoring plans to guide the spill response, and assess potential environmental impacts.

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			An Inspection Monitoring and Maintenance Program will be developed for the gas export pipeline to assess structural integrity and for any potential leaks. A simultaneous operations (SIMOPS) procedure will be implemented to control and manage any concurrent SIMOPS activities. *Long-term well blowout prevention* All well design and control activities will be undertaken in accordance with a NOPSEMA approved WOMP and as detailed in activity-specific EPs. All drilling activities will be undertaken in accordance with accepted procedures that meet the requirements of the: • ConocoPhillips Well Construction and Intervention standard, which outlines minimum requirements (including testing and maintenance) for well control equipment (e.g. blowout preventer, casings/tubings and drilling mud systems) • ConocoPhillips Well Design and Delivery Process documentation including Well Engineering Basis of Design, Critical Well Review and Shallow Hazard Study • ConocoPhillips Wells Management System, which includes the requirement for a minimum of two barriers that are tested and maintained during all well operations. A MODU/drill ship Safety Case Revision will be developed and implemented, which describes the ConocoPhillips and MODU Operators agreed well control interface.	• The key management measures align with relevant legislative requirements, standards, industry guidelines and ConocoPhillips HSEMS, HSE Policy, SD Policy, and Company standards and systems. • The comprehensive preventative management and response arrangements that ConocoPhillips has in place. • The approach applied to the project is consistent with the principles of ESD, as discussed below: • Of particular relevance to this aspect: • Physical environment (water quality and sediment quality) – the impact evaluation identifies the low probability of unplanned discharges and the potential evaluation of consequences, as relevant to the existing environment relevant to this proposal.	

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			Vessels/facilities The FPSO facility will be designed so that hull shall be double hull or double sided and compartmentalised condensate storage tanks. Vessel specific controls will align with MARPOL 73/78 and Australian Marine Orders (as appropriate for vessel classification), which includes managing spills aboard, emergency drills and waste management requirements. Vessel movements will comply with maritime standards such as COLREGS and Chapter V of SOLAS. Offtake vessels will be piloted during berthing and offloading operations. Visual monitoring of the offloading manifold and hose will be maintained during offtake operations to allow for rapid emergency shut down. All marine contracted vessels will undergo the ConocoPhillips Global Marine vetting process, which involves inspection, audit and a review assessment for acceptability for use, prior to working on the project. Vessel selection criteria will make considerations for designs and operations which reduce the likelihood of hydrocarbon spills to the marine environment as a result of a vessel collision. All vessels involved in the project will have a valid SOPEP or SMPEP (as appropriate for vessel classification).	• Benthic habitats (including shoals and banks, Tiwi Islands, other offshore reefs and islands and mainland coastline) – the key management controls that will be implemented take into consideration the key values and sensitivities of the marine environment within the area of influence from a potential spill and are considered to manage potential impacts and risks to an acceptable level. An activity-specific OPEP that demonstrates adequate arrangements for responding to and monitoring oil pollution, in the event of a major unplanned release, will be accepted by NOPSEMA prior to commencing the activity.	

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
			Response measures (refer to **Section 7.2.2** for further discussion of emergency preparedness and response) Spill response in the event of a hydrocarbon or chemical spill will be implemented safely and be commensurate with the type, nature, scale and risks of the spill to key values and sensitivities, as defined in activity-specific OPEPs. A Crisis Management Plan will be implemented in the event of a spill, which includes: • emergency response planning • emergency management structure • incident notification • emergency response responsibilities and support providers. An OSMP will be initiated and implemented as appropriate to the nature and scale of the spill and the existing environment, as informed by a net environmental benefit assessment. ConocoPhillips will have additional contingency plans in place in the event of a well blowout, including side track relief well drilling, well capping and existing contracts with spill response agencies to facilitate efficient implementation of appropriate spill response measures.	• Marine fauna (including marine mammals, marine reptiles, birds and fish) - the project aligns with applicable management/ recovery plans and conservation advices. **Table 6-47** demonstrates how the project aligns with the requirements of applicable MNES management plans, as defined in **Section 3.5** relevant to the key factors for this aspect. Consistent with the above conclusion, the application of key controls to be applied at all stages of the proposal, will be implemented to minimise risk. No population level impacts are expected as a result of unplanned discharges, although individuals may be affected in the area of influence that is dependent on the nature and scale of a potential release, and the appropriate spill response framework.	

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
				ConocoPhillips has been operating in Australia and the Joint Petroleum Development Area since the mid-1990s. The Company is successfully operating the Bayu-Undan gas condensate field and has successfully completed a number of drilling campaigns in the Timor Sea and Browse Basin through its Australian business units without major incident. Operations at Bayu-Undan have included the safe transfer of hydrocarbons to tankers offshore and more than 600 shipments to overseas markets. Titles for oil and gas exploration are released based on commitments to explore with the aim of uncovering and developing resources. To satisfy offshore permit retention lease requirements, ConocoPhillips has an obligation to undertake exploration in the Barossa offshore development area and develop commercially viable hydrocarbon reserves in a safe and responsible manner. The conservation of biological diversity and overall ecosystem integrity has been considered in the environmental risk assessment, and has been informed by a detailed understanding of the existing marine environment within the Barossa offshore development area and surrounds (**Section 5**). Specifically, ConocoPhillips has undertaken a comprehensive and robust environmental baseline studies program to characterise the existing marine environment (**Section 5.2**).	

Aspect	Key factors	Potential impact for key factors	Key management controls	Acceptability	Environmental performance outcome
				Where limited scientific information exists within the area of influence, ConocoPhillips conservatively assumes that the marine environment is of high inherent value and, therefore, implements all practicable/ feasible measures to prevent potential impacts. ConocoPhillips corporate HSE Policy and SD Position outline expectations and principles of operations that require consideration of sustainability, the environment and communities within areas in which the Company operates (**Figure 2-2** and **Figure 2-3**). ConocoPhillips recognise there is an inherent risk of unplanned discharges in undertaking the project. However, through the implementation of established and comprehensive policies, standards, procedures and processes, in conjunction with relevant legislation, ConocoPhillips considers that despite this risk, the extremely low likelihood of a significant spill event (e.g. vessel collision leading to a significant loss of hydrocarbons or long-term well blowout) being realised is broadly acceptable. ConocoPhillips also considers the overall level of risk is broadly acceptable as the likelihood of such an event occurring during the project is similar to the Bayu-Undan operations, which has not had a significant spill event since installation activities commenced in 2004.	

6.5 Cumulative impacts

Cumulative impacts may result from the long-term cumulative effects of a project over time (i.e. in a temporal context), or may include the cumulative effects of other activities in the area (i.e. in a spatial context). Therefore, in assessing the overall acceptability of a project, it is important to consider potential significant cumulative impacts and risks.

6.5.1 Scope of the assessment

The cumulative impact assessment presented in this OPP takes into consideration potential project impacts and impacts of other activities, including existing activities and potential future oil and gas developments.

The activities included in the assessment have been defined according to the following criteria:

- activities not already assessed previously in this OPP (i.e. not taken into consideration as part of the existing environment or baseline conditions)
- activities which have aspects that may impact the same values and sensitivities as the project. Considering the small spatial extent of potential impacts resulting from planned project activities and operations (**Section 6.4.1** to **Section 6.4.9**), activities more than a 150 km radius from the project (Barossa offshore development area and gas export pipeline) have been excluded. This is considered a highly conservative buffer given the physical footprint of the project and that planned discharges are expected to be well below levels of environmental significance within a radius of approximately 21 km from the discharge location in the Barossa offshore development area. The buffer is also considered conservative in terms of any potential exclusion zones that may be put in place in the unlikely event of a large-scale unplanned release.
- activities that exist or have a high degree of certainty of proceeding in the future, such as those under construction or for which approvals and capital investment have been obtained
- activities for which sufficient information is available to conduct a qualitative assessment to a reasonable standard.

As described in **Section 5.7**, a number of activities currently exist within or in close proximity to the project, specifically commercial fishing (Commonwealth and NT-managed fisheries) and shipping. As outlined in **Section 5.7.18**, while a number of oil and gas companies hold petroleum permits in the vicinity of project, there are no established operations within, or in the immediate surrounds. The closest operational production facility to the Barossa offshore development area is the Bayu-Undan platform approximately 360 km to the west-south-west. For the purposes of the OPP, the cumulative impact assessment takes into consideration offshore oil and gas projects that will be of comparable spatial and temporal scales, and their potential to interact with the project. For example, the assessment considers offshore oil and gas activities at a whole-of-project level (e.g. Bayu-Undan project, Ichthys project) as opposed to individual oil and gas appraisal and exploration activities (e.g. appraisal drilling, seismic surveys). The assessment also takes into account all key stages and aspects of the potential projects, as discussed in **Section 4,** which aligns with the whole-of-life-cycle view to be taken at an OPP level of assessment.

The assessment considers both existing and reasonably foreseeable offshore oil and gas projects and provides a qualitative evaluation of these activities, noting the inherent difficulties associated with accessing commercial-in-confidence data associated with other proposed developments.

A summary of the activities considered in the cumulative impact assessment is provided in **Table 6-49**.

In addition to the activities considered in **Table 6-49,** it is understood that potential development of the Evans Shoal Field (approximately 10 km north-north-west from the Tassie Shoal project) remains under evaluation. At the time of publication of this OPP, no field development plans are available and therefore unable to be meaningfully incorporated into this assessment.

Table 6-49: Activities considered in the cumulative impact assessment

Activity	Description	Status	Included in cumulative impact assessment
INPEX Masela Abadi FLNG project	The potential development is located approximately 10 km (closest point) to the north of the Barossa offshore development area in Indonesian waters in the Arafura Sea. The proponent's current preferred development plan is a FLNG facility.	Indonesian authorities have approved an initial development plan of a FLNG facility. INPEX are evaluating methods to optimise development plans centred on a large-scale FLNG and are in discussions with the Indonesian government. The Indonesian Government is seeking an onshore LNG processing option to be considered. This remains uncertain at the time of publication, and the project is on hold.	Yes
Melbana Energy (previously MEO) Tassie Shoal methanol project	The potential development is located approximately 37 km to the west of the Barossa offshore development area in the Timor Sea. The potential Tassie Shoal project would comprise one LNG and two methanol production facilities.	Approved. Updated environmental approvals extending the approvals period for the project to 2052, and increasing the flexibility to process gas of varying qualities into LNG, were received in August 2016.	Yes
Other marine users	Commercial fishing and shipping	Existing – these activities are ongoing and are not anticipated to significantly change in the immediate or near future in terms of scale or location.	No – as these activities are existing they are considered as part of the existing baseline socio-economic environment (**Section 5.7**). Therefore, the potential impacts and risks to these activities associated with the project have been considered and assessed in detail as part of the project specific impacts and risks assessment (**Section 6.4**).

6.5.2 Assessment of cumulative impacts

A summary of the cumulative impact assessment is presented in **Table 6-50**.

Table 6-50: Cumulative impact assessment summary

Aspect	Summary of assessment
Physical presence of offshore facilities/ infrastructure, equipment and project related vessel movements	*Offshore facilities/infrastructure and equipment* The physical presence of project facilities/infrastructure, equipment and vessels will not have a cumulative impact on marine fauna as it represents a small physical footprint in the context of known regional migratory movements and patterns. While interactions with other marine users are considered remote, given the relatively minor physical scale of the project, combined with the relatively low level of activity within the open offshore waters of the project area, the potential cumulative impact of oil and gas petroleum safety zones restricting commercial fishing areas is acknowledged. However, the petroleum safety zones associated with oil and gas projects are spatially small (typically 500 m radius) compared to the area available to commercial fisheries. The risk of significant cumulative impacts from the physical presence of infrastructure associated with the project in combination with the Abadi and Tassie Shoal projects, even if the project activities coincide temporally, is therefore low. *Vessel movements* Vessel movements will be associated with all stages of the Barossa, Abadi and Tassie Shoal projects. The presence of vessels is expected to be similar for all of the projects, with peak numbers anticipated during installation activities. The potential environmental impacts associated with vessels are considered to be largely similar for offshore oil and gas developments in terms of interactions with marine fauna and planned emissions (e.g. light and air) and discharges (e.g. cooling water and wastewater). As the majority of the vessel movements will be within the vicinity of each project's facilities/infrastructure and equipment (e.g. FPSO/FLNG facility and subsea infrastructure), overlap of each project's vessel movements is considered unlikely. In addition, given the broad marine area and the open shipping navigational areas available for vessels in the Timor Sea, this potential for impact 'in-field' is very low. Therefore, the risk of cumulative impacts at a local scale from associated with the project in combination with the Abadi and Tassie Shoal projects is low. At a regional scale, there may be a minor cumulative impact associated with the concurrent transit movement of vessels between Darwin and the Barossa and Tassie Shoal project areas. However, it is unlikely that installation activities would occur at the same time for both projects, which is when vessel movements between Darwin and the project areas would be highest. While noting that it is outside the scope of this OPP, a more plausible cumulative impact scenario is the concurrent demand for vessel supply/berthing needs in Darwin, which is more relevant to a future NT-specific project planning need. To date the NT Government has managed this demand by expanding its port facilities and allowing dedicated marine supply bases in the area. This potential cumulative impact will be managed as part of the forward logistical planning at a 'whole-of project' level.

Aspect	Summary of assessment
Seabed disturbance	The physical presence of project facilities/infrastructure, equipment and vessels will not have a significant cumulative impact on the seabed features and the benthic environment as it represents a small physical footprint in the context of the Timor Sea. The physical footprint of the Abadi and Tassie Shoal projects, should they proceed, will be smaller in scale in comparison to the Barossa project as the current development concepts proposed do not require a gas export pipeline. As a surrogate for a FLNG concept comparable to Abadi, the Browse FLNG development EIS stated a seabed footprint of approximately 67 ha for all subsea infrastructure, and this may be used as a conservative estimate. Should the Abadi project proceed as an onshore LNG concept, a gas export pipeline would be required but would be installed in Indonesian waters. The approved Tassie Shoal proposal included the installation of two concrete gravity structures, with a total development footprint of approximately 7 ha cited in the referral for the LNG component of the development (Gastech Systems 2003). Taking into account additional seabed disturbance from subsea infrastructure and rock armouring that was not quantified, an indicative total footprint for Tassie Shoal may be in the order of 10–15 ha for broad comparison purposes. The Tassie Shoal project is likely to occur within a small portion of the KEF of the shelf break and slope of the Arafura Shelf (approximately 10,844 km^2) and/or carbonate bank and terrace system of the Van Diemen Rise (approximately 31,278 km^2). However, significant cumulative impacts are not expected given the small spatial extent of the project in the context of the overall area covered by the KEF. As a conservative estimate, the total cumulative footprint of Barossa, Abadi and Tassie Shoal projects represent 143 ha, or 0.003% of the total KEF areas of 42,122 km^2 (4,212,200 ha). Therefore, the risk of significant cumulative impacts from seabed disturbance associated with the project in combination with the Abadi and Tassie Shoal projects is low.
Biosecurity (IMS)	As discussed in **Section 6.4.4**, the risk of introducing IMS is inherently limited by the location of the Barossa offshore development area in deep waters (130 m–350 m) that are not directly adjacent to any shoals/banks. Given the location of the Abadi project in deep offshore waters (400 m–900 m), the risk profile for this project is expected to be similar. The Tassie Shoal project is proposed to be located in shallow waters (approximately 15 m). However, in a local context, MODU/drill ships and vessels associated with the project are not expected to overlap vessel movements associated with the Tassie Shoals project, should it proceed. Therefore, no significant cumulative impacts are expected.
Underwater noise emissions	Underwater noise emissions are expected to be greatest during the installation stages of the project which will extend for a relatively short period in the context of the project life. Therefore, the risk of cumulative impacts associated with underwater noise generated during installation of the Barossa, Abadi and Tassie Shoals projects is assessed as low. Long-term, ongoing underwater noise emissions will be generated during operation of the project. As discussed in **Section 6.4.5**, underwater noise modelling during normal operations and offtake predicted that noise levels of 120 dB re 1µPa would occur within approximately 1.4 km and 11.4 km, respectively. In terms of underwater noise that may be emitted from an FLNG facility, the Browse FLNG Development can be used as a surrogate for the Abadi project; while noting that the different localities, seabed and bathymetric profiles will affect the actual area influenced. Underwater noise modelling for the Browse FLNG Development predicted that underwater noise emissions during normal operations and offloading activities at the FLNG facilities at Torosa would fall below 120 dB re 1 µPa approximately 4 km and approximately 10 km respectively from the facility (Woodside 2014). Considering the short distance between the Barossa offshore development area and the Abadi project (approximately 10 km at the closest point), there may be minimal overlap of underwater noise emissions for the projects. However, this is considered highly unlikely as the Barossa FPSO facility is not proposed to be located in close proximity to the northern boundary of the Barossa offshore development area as it will be within the Barossa Field. Therefore, the Barossa FPSO facility and Abadi FLNG facility will be greater > 20 km apart and no significant cumulative impacts are expected.

Aspect	Summary of assessment
Atmospheric emissions	Atmospheric and GHG emissions will be produced throughout the life of the Barossa, Abadi and Tassie Shoal projects. In a local context, atmospheric emissions disperse relatively rapidly and therefore cumulative impacts are not expected. At domestic and global scales, the project will result in an incremental increase in GHG concentrations.
Light emissions	Light emissions will be associated with all stages of the Barossa, Abadi and Tassie Shoal projects. Given the relative proximity of the Masela Abadi project (approximately 10 km to the north at the closest point to the Abadi Field) and Tassie Shoals project (approximately 37 km to the west), and taking into consideration the results of the Browse FLNG Development light density modelling study (**Section 6.4.7**), there may be some overlap in light emissions from the projects. For example, the modelling predicted that light density levels of 0.025–0.05 Lux (comparable to light levels between a quarter moon and a full moon) and less than 0.002 Lux (comparable to a clear to overcast moonless sky) would occur between 7 km and 10 km and beyond 33 km, respectively (Woodside 2014). This may lead to an incremental increase in light emissions predominantly over open ocean waters, with very slight additive increases at Tassie Shoal and Evans Shoal possible. However, these cumulative increases are expected to be minimal and are therefore not expected to have a significant cumulative impact on marine fauna.
Planned discharges	Planned discharges to the marine environment, such as drill cuttings and fluids, cooling water and wastewater, will be associated with the various stages of the Barossa, Abadi and Tassie Shoal projects. As demonstrated in **Section 6.4.8**, conservative modelling of the planned discharges for the project predicted that the discharges would be below levels of environmental significance within a conservative radius of approximately 21 km from the discharge location. Planned discharges from the Abadi and Tassie Shoal developments such as PW and cooling water will also be localised and expected to disperse rapidly within close proximity to discharge points, with no expected cumulative effect from liquid discharges associated with the project. Daily discharge volumes of PW and cooling water for these projects are not published, therefore limited direct comparison can be made. The locational context of the Barossa offshore development area is an open ocean environment, a localised impact zone as informed by modelling studies, with a separation distance from nearby sensitive environmental values/ sensitivities and other potential field developments central to the project planning. A monitoring program will be established to verify that concentrations of planned discharges will meet relevant ANZECC/ARMCANZ guidelines (or within natural variation or background concentration) beyond the predicted mixing zone(s). Considering this, no significant cumulative impacts from planned discharges of PW and cooling water are expected. Subject to schedule requirements and availability, concurrent drilling using two MODUs/ drill ships may be considered during development drilling. The drilling method would be identical and therefore the planned emissions and discharges would be duplicated, but for a shorter period. The well drilling planned discharges will be a significantly smaller volume and for a shorter duration in comparison to operations, confined to a localised impact footprint. Therefore, no cumulative impacts are anticipated.
Waste management	Discharge of hazardous and non-hazardous waste to the marine environment is not proposed as part of the project, with the application of good practice waste handling and management. Therefore, no material cumulative impacts are anticipated.
Unplanned discharges	While ConocoPhillips acknowledge that large-scale releases have occurred from offshore oil and gas activities, the risk of cumulative impacts from unplanned discharges is considered extremely remote. As outlined in **Section 7.2.2**, each proponent or titleholder is required to have an approved OPEP in place prior to commencing the activity. In addition, in the very unlikely event of an unplanned release, mutual arrangements are in place for offshore titleholders to support in the rapid response effort, in coordination with responsible agencies such as AMSA.

6.5.3 Cumulative impacts conclusion

The project will not result in any material cumulative impacts to the marine environment at a local scale as there is no significant overlap with other proposed offshore oil and gas projects. No cumulative impacts to MNES, particularly EPBC listed species, are expected. Therefore, the residual risk rankings detailed in **Section 6.4** of this OPP remain unchanged.

Regional cumulative impacts may occur in terms of incremental increases in vessel movements and GHG emissions. However, these have been assessed as minor and do not change the residual risk rankings for any of the potential impacts assessed in this OPP (**Section 6.4**).

7 Environmental performance framework

Section 7 summary

Purpose:

This section summarises the environmental performance outcomes (EPOs) that will be applied by ConocoPhillips to protect the environment while developing and operating the Barossa project. EPOs are designed to ensure the environmental risks and impacts are managed to an acceptable level.

This section also summarises ConocoPhillips' emergency response preparation and response measures for the unlikely event of an unplanned release of hydrocarbons, our environmental monitoring framework and concludes on project acceptability.

Section at a glance:

It is recognised that relevant regulations, codes, standards and guidelines may change over the life of the project. Any changes will be addressed through the development of the EPs at the time of the activity.

The development of appropriate EPOs is informed by ConocoPhillips' history of safe, reliable and environmentally responsible exploration and appraisal activities in the Timor Sea over the past decade and includes controls that are tailored to the management of key impacts and risks evaluated in **Section 6**. It is recognised that it is impossible to eliminate all risks. So, the aim becomes to ensure every activity is conducted in a manner that is safe, responsible and acceptable once all the impacts and risks have been properly and fully considered.

Implementation strategy

While a detailed implementation strategy will be presented in subsequent activity-specific EPs, a high-level outline of emergency preparedness measures, including operational and scientific monitoring plans, and environmental monitoring that will be applied to manage environmental impacts and risks associated with the project to assist achieving the EPOs, is provided.

Project acceptability

As a result of the risk-based assessment documented in the OPP, ConocoPhillips considers the project to be acceptable, given that:

- the remote project location of the Barossa offshore development area, which is predominantly located in deep, open offshore waters, means no facilities will be placed near any areas of regional environmental importance such as shoals, banks, coral reefs or biologically important areas for marine fauna
- planned operations have a relatively limited extent, with the impacts and risks considered low
- the risk of unplanned releases is medium, however the likelihood is remote given comprehensive management controls will be implemented
- the implementation of key management controls and clear definition of appropriate and measurable EPOs that will assist in managing all environmental aspects of the project
- the project will be undertaken in accordance with relevant legislation, standards and industry guidelines, consistent with the principles of ESD and ConocoPhillips expectations for responsible environmental management.

Consistency with the principles of ecologically sustainable development

ConocoPhillips considers the project to be consistent with the principles of ESD, as defined in the EPBC Act. Protection of the environment was a key consideration for the environmental impact and risk assessment process, as informed by a detailed understanding of the existing marine environment. Protection has been further provided for through definition of key management controls and EPOs for the project. The assessment presented within this OPP relates to the entire life-cycle of the project, and therefore takes into account both short-term and long-term considerations and potential impacts associated with the project. Within this context, a comprehensive management framework will be implemented, appropriate to the nature and scale of the project to achieve acceptable outcomes.

7 Environmental performance framework

7.1 Introduction

This section of the OPP defines project EPOs that will be applied to manage the environmental impacts and risks associated with the development (as discussed in **Section 6**) to an acceptable level. As defined by NOPSEMA (2016a), an EPO is a *"measurable level of performance required for the management of environmental aspects of the project to ensure that the environmental impacts and risks will be of an acceptable level."*

The EPOs associated with the project are appropriately high-level at this early stage of project development and focus on providing overall environmental protection for the life of the project. The high-level nature of the EPOs also aligns with the intent of an OPP and its specific role early in the regulatory approval cycle, that precedes development and acceptance of more detailed EPs. The EPOs are expected to be refined and/or further detail provided in subsequent activity-specific EPs to reflect improved definition of environmental impacts and risks and controls associated with execution-level activity detail.

The EPOs provided in **Table 7-1** are relevant to the environmental impacts and risks associated with the project and consistent with the ConocoPhillips HSE Policy, SD Position, HSEMS and CPMS (**Section 2**), principles of ESD and relevant legislative requirements, codes, standards and guidelines (**Section 3**).

It is recognised that relevant requirements, codes, standards and guidelines change over time, over the life of this OPP approval. While specific reference is made to some of these current requirements in this OPP, it is noted that future activity-specific EPs will take into account contemporary requirements at the time of the activity.

As a guide, the information presented in **Table 7-1** provides a direct link to the outcomes of the risk-based impact assessment as concluded from **Section 6** of this OPP, and includes:

- key management controls: consistent with those controls described in **Section 6** to achieve an acceptable level of environmental protection
- EPOs: outcome statements of environmental performance to be achieved through implementation of key controls in the previous column.

This section aligns with the NOPSEMA OPP Content Requirements Guidance Note (NOPSEMA 2016a): *"To provide appropriate environmental performance outcomes that are consistent with the principles of ecologically sustainable development; and demonstrate that the environmental impacts and risks of the project will be managed to an acceptable level."*

Table 7-1: Barossa OPP EPOs

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Physical presence of offshore facilities/ infrastructure, equipment and project related vessels – interactions with other marine users	Commercial fishing. Recreational fishing. Commercial shipping. Offshore petroleum exploration operations.	Interference with and/or exclusion of commercial/ recreational fishing vessels, commercial shipping or other marine users. Business interruption (abnormal) to the activities of other marine users due to damage to commercial vessels or fishing gear. Interaction with other petroleum titleholder operations or exploration activities.	The project will comply with the OPGGS Act 2006 – Section 616 (2) Petroleum safety zones, which includes establishment and maintenance of a petroleum safety zone around the well, offshore structure or equipment which prohibits vessels entering or being present within the specified area without written consent. Accepted procedures will be implemented to meet the requirements of ConocoPhillips' Marine Operations Manual (IOSC/OPS/HBK/0003), which includes details of: • roles, responsibilities and competency requirements • requirements (e.g. storage, transfer) for bulk cargo and bulk liquids (including bunker fuel) operations • general requirements for entering/departure and movement within the designated exclusion or petroleum safety zones • checklist required to be completed for vessels entering the exclusion zones in the development area • safe and sustainable dynamic positioning operations. The Stakeholder Engagement Plan will include consultation with commercial fisheries, shipping, AHO and other relevant stakeholders operating in the Barossa offshore development area and gas export pipeline to inform them of the proposed project. Ongoing consultation will also be undertaken throughout the life of the project. The FPSO facility will be located away from key commercial shipping channels. The location of the FPSO facility will be communicated to other ships through a Notice to Mariners from the AHO. Subsea infrastructure and pipelines will be clearly marked on Australian nautical charts published by the AHO. Project-vessels operating within the Barossa offshore development area and gas export pipeline corridor will comply with maritime standards such as COLREGS, Chapter V of SOLAS, Marine Order 21 (Safety of Navigational and Emergency Procedures) and Marine Order 30 (Prevention of collisions) (as appropriate to vessel class).	Fixed offshore facilities/ infrastructure and equipment in the Barossa offshore development area will not be located in key areas of importance for commercial fishing and other marine users. Fixed offshore facilities/ infrastructure and equipment in the Barossa offshore development area will not be located in key areas of importance for commercial fishing and other marine users. No vessel collisions or significant adverse interactions with other marine users.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Physical presence of offshore facilities/ infrastructure, equipment and project related vessels – interactions with marine fauna	Marine mammals. Marine reptiles.	Injury or mortality of conservation significant fauna. Change in marine fauna behaviour and movements.	The project will be undertaken in accordance with ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as: • design planning throughout concept select phase to avoid placement of facilities/ infrastructure within the Barossa offshore development area in areas of regional environmental importance (e.g. shoals/banks, coral reefs, islands, and known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles). • use of gas export pipeline selection route surveys to inform route optimisation and reduce environmental impact. Screens will be installed on the FPSO facility cooling water intakes to minimise the potential risk of causing injury/mortality to marine fauna. The interaction of the vessels associated with the project with listed cetacean species will be consistent with the EPBC Regulations 2000 - Part 8 Division 8.1 Interacting with cetaceans (except in emergency conditions or when manoeuvring is not possible, such as in the case of pipelay activities), which include: • vessels will not knowingly travel > 6 knots within 300 m of a whale • vessels will not knowingly approach closer than 100 m to a whale • vessels will not knowingly restrict the path of cetaceans. Vessel speed restrictions will be implemented within the defined operational area of the gas export pipeline route, except where necessary to preserve the safety of human life at sea. This will be reinforced through training of selected vessel crew to sight and manage interactions with turtles. Personnel associated with vessel activities will be subject to project inductions which will address the requirements for vessel operators in relation to interactions with marine fauna. No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods.	Fixed offshore facilities/ infrastructure and equipment in the Barossa offshore development area will not be located in regionally important feeding and breeding/nesting biologically important areas for marine mammals or marine reptiles. Vessel speeds restricted in defined operational areas within the project area, to reduce the risk of physical interactions between cetaceans/marine reptiles and project vessels. Zero incidents of injury/mortality of cetaceans/marine reptiles from collision with project vessels operating within the project area. No significant impacts to turtle populations from installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			Installation schedule of the gas export pipeline will take into consideration seasonal presence/ activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Seabed disturbance	Physical environment – seabed features. Marine reptiles. Shoals and banks. AMPs – Oceanic Shoals. KEF – shelf break and slope of the Arafura Shelf, and the carbonate bank and terrace system of the Van Diemen Rise.	Direct loss or indirect disturbance of benthic habitat. Physical damage and/ or disturbance to unique seafloor KEFs. Physical damage and/ or disturbance to benthic habitat within the Oceanic Shoals marine park and to shoals/ banks.	The project will be undertaken in accordance with the ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as: • design planning throughout concept select phase to avoid placement of facilities/ infrastructure within the Barossa offshore development area in areas of regional environmental importance (e.g. shoals, banks, coral reefs, islands, and known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles • use of export pipeline selection route surveys to inform route optimisation and reduce environmental impact. The location of subsea infrastructure within the Barossa offshore development area will be informed by pre-installation surveys/studies that identify and avoid areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles). Pre-lay surveys of the gas export pipeline installation route will be used to identify areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf and carbonate bank and terrace system of the Van Diemen Rise KEFs, seabed related conservation values associated with the Oceanic Shoals marine park or nearby shoals and banks (including Goodrich Bank, Marie Shoal and Shepparton Shoal). The outcomes of the pre-lay surveys will be used to inform route optimisation and reduce environmental impacts. The MODU/FPSO facility mooring design analysis will include environmental sensitivity and seabed topography analysis to inform selection of mooring locations to avoid areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles). Positioning of the MODU will be undertaken in accordance with the mooring design and analysis and the drilling contractors' rig move procedure, which includes procedures for the deployment and retrieval of anchors using support vessels to minimise seabed impacts. Shallow Hazards Study report will be completed prior to drilling of the development wells and include a review of seabed features to inform well location. A Vessel Anchoring Plan will be prepared which will take into consideration anchoring locations and will confirm no anchoring on shoals/banks. Heavy lifting operations between vessels and the MODU/drill ship or FPSO facility will be undertaken using competent personnel appropriate and certified lifting equipment and accessories to minimise the risk of dropped objects.	No permanent disturbance to benthic habitats beyond the physical footprint of offshore facilities/infrastructure within the Barossa offshore development area and gas export pipeline, as relevant to both direct and indirect sources of disturbance to seabed and associated benthic habitats. The FPSO facility and in-field subsea infrastructure will be located in the Barossa offshore development area and will not impact the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (which are > 27 km away) and areas of seabed that are associated with the shelf break and slope of the Arafura Shelf KEF. No anchoring or mooring of the FPSO facility and MODU/vessels on shoals/banks, except in emergency conditions. Minimise disturbance beyond the physical footprint by preventing the loss of significant equipment/ cargo overboard from the MODU/ drill ship, FPSO facility or vessels. The gas export pipeline route will be designed to minimise, where practicable, areas of seabed that are associated with the seafloor features/values of KEFs and shoals/ banks.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. Dredging activities/trenching activities for the gas export pipeline installation (if required) will occur outside the peak flatback (June to September) and olive ridley (April to August) turtle internesting period when within the internesting habitat critical to the survival of these species. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions). Further surveys within the pipeline corridor will be used to supplement existing knowledge from habitat assessments to date, to support an evaluation of the representativeness of species and species assemblages found within the portion of the gas export pipeline corridor that intersects the Oceanic Shoals marine park, with other areas of the marine park.	To minimise impact to representative species, assemblages and associated values of the Oceanic Shoals marine park, further studies will be used to inform final pipeline routing so the pipeline will not be installed on those representative species, assemblages and associated values if they have not been found in the marine park outside the pipeline corridor. No significant impacts to turtle or dugong populations from impacts (direct or indirect) associated with installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			If trenching/dredging activities for the gas export pipeline installation are required, i.e. if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, they will occur outside the peak flatback (June to September) and olive ridley (April to August) turtle internesting period. The following process will be used to identify how the pipeline in the section to be trenched/dredged will be installed to reduce impacts and risks to ALARP and acceptable levels: 1. undertake numerical modelling to predict the extent, intensity and persistence of sediment plumes arising from trenching/dredging activity 2. use the outputs of the numerical modelling to identify key environmental values/sensitivities at risk from trenching/dredging activities with consideration of background/baseline conditions and any seasonal presence 3. update of latest knowledge of how aspects arising from trenching/dredging activities can impact the marine environment, including marine turtles and benthic communities 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above with the understanding of the environment (e.g. benthic habitat maps) to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP, i.e. confirm impacts from trenching/dredging will be temporary and localised. Note: if required, additional controls and/ or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. 5. develop a dredge management plan that: • details how trenching/dredging will be undertaken (which will be informed by the information derived from items 1-4 above) • identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels • includes an adaptive management strategy for how trenching/dredging activity will be managed, including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised	

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			If use of an anchored pipelay vessel is required, i.e. it may only be required if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, the following process will be used to identify how anchored pipelay installation will be undertaken to reduce impacts and risks to ALARP and acceptable levels: 1. use the information and data derived from the pre-lay survey of the gas export pipeline installation route to update understanding of the existing environment along the gas export pipeline route 2. identify any anchor restrictions zones, i.e. areas where anchors cannot be placed, e.g. shoals, banks or coral outcrops 3. define how installation of the pipeline would be undertaken including start-up anchor pattern, operational anchor pattern and lay down (ending) anchor pattern, and predict the number of anchor drops required 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from 1, 2 and 3, with consideration of any seasonal presence, to evaluate the environmental impacts and risks and to verify the impact assessment conclusions are consistent with those presented in this OPP (Note: if required, additional controls and/or mitigation measures will be identified to be implemented to demonstrate consistency with the impact assessment presented in this OPP) 5. develop a pipeline lay anchoring management plan that: • identifies how pipelay installation would be undertaken using an anchored pipelay vessel • identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels • includes an adaptive management strategy for how anchoring activity will be managed including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised.	

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
IMS (biosecurity)	Shoals and banks. KEFs – shelf break and slope of the Arafura Shelf, and the carbonate bank and terrace system of the Van Diemen Rise.	Displacement of native marine species. Reduction in species biodiversity and decline in ecosystem integrity, particularly of shoals/banks.	A Quarantine Management Plan will be developed and implemented, which will include as a minimum: • compliance with all relevant Australian legislation and current regulatory guidance • outline of when an IMS risk assessment is required and the associated inspection, cleaning and certification requirements • implementation of management measures commensurate with the level of risk (based on the outcomes of the IMS risk assessment), such as inspections and movement restrictions • anti-fouling prevention measures including details on maintenance and inspection of anti-fouling coatings. Ballast water exchange operations will comply with the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 – MARPOL 73/78 (as appropriate to vessel class), Australian Ballast Water Management Requirements (DoAWR 2017) and Biosecurity Act 2015, including: • all ballast water exchanges conducted > 12 nm from land and in > 200 m water depth • vessel Ballast Water Management Plan stipulating that ballast water exchange records will be maintained • completion of DoAWR Ballast Water Management Summary sheet for any ballast water discharge in Australian waters. The International Convention on the Control of Harmful Anti-fouling Systems on Ships will be complied with, including vessels (of appropriate class) having a valid IAFS Certificate. The FPSO facility hull will be subject to an IMS inspection prior to entry into Australian waters.	Prevent the displacement of native marine species as a result of the introduction and establishment of IMS via project-related activities, facilities and vessels.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Underwater noise emissions	Marine mammals. Marine reptiles. Fish. Sharks and Rays.	Behavioural disturbance or physiological damage, such as hearing loss, to sensitive marine fauna. Masking or interference with marine fauna communications or echolocation.	The project will be undertaken in accordance with the ConocoPhillips' CPMS, which provides the framework to achieve acceptable health, safety and environment outcomes such as: • the design of offshore facilities/infrastructure to consider engineering measures to minimise operational noise emissions • placement of project facilities/infrastructure within the Barossa offshore development area to avoid known regionally important feeding and breeding/nesting biologically important areas for marine mammals and marine reptiles or shoals/banks. Key noise-generating equipment will be maintained in accordance with the manufacturer's specifications, facility planned maintenance system and/or regulatory requirements. Any VSP activities conducted at the development well will comply with 'Standard Management Procedures' set out in EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales: Industry Guidelines (DEWHA 2008d) (or the contemporary requirements at the time of the activity), specifically: • pre start-up visual observations. Visual observations for the presence of whales by a suitably trained crew member will be carried out at least 30 minutes before the commencement of VSP. • start-up and normal operating procedures, including a process for delayed start-up, should whales be sighted. Visual observations by trained crew should be maintained continuously. • night time and low visibility procedures. If required, pile driving activities will align with the Department of Planning, Transport and Infrastructure (2012) 'Underwater Piling Noise Guidelines' which have been adapted from EPBC Act Policy Statement 2.1 (or the contemporary requirements at the time of the activity). The guidelines include: • safety zones – observation and shutdown zones • standard management and mitigation procedures, e.g. pre-start, soft start, normal operation, stand-by and shut-down procedures • consideration of additional management and mitigation measures, e.g. increased safety zones and marine mammal observers. No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods.	The outer boundary of the planned operational noise footprint (approximately 12 km from source) within the Barossa offshore development area will not impact the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (located > 27 km away). The use of FPSO facility thrusters will be limited to that required for safe operations and working requirements. No significant adverse impacts to marine fauna populations from VSP operations or pile driving activities. No significant impacts to turtle populations from noise generated during installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			Installation schedule of the gas export pipeline will take into consideration seasonal presence/ activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Atmospheric emissions	Physical environment – air quality	Localised reduction in air quality. Contribution to the incremental build-up of GHG in the atmosphere.	All MODUs/drill ships and vessels (as appropriate to vessel class) will comply with Marine Order 97 (Marine pollution prevention – air pollution), which requires vessels to have a valid IAPP Certificate (for vessels > 400 tonnage) and use of low sulphur diesel fuel, when possible. The sulphur content of fuel used by project vessels will comply with Regulation 14 of MARPOL Annex VI (as appropriate to vessel class) in order to control SO_x and particulate matter emissions. Fuel gas will be used as the preferred fuel for FPSO processes during operations (instead of diesel or marine gas oil). Engineering design of the FPSO facility will seek to reduce atmospheric and GHG emissions through energy efficient design. ConocoPhillips will complete and submit annual NGER reports during the operations stage of the project for the Kyoto Protocol listed (or applicable post-Kyoto agreement at the time of operations) GHG emissions on a CO_2 equivalency basis for each facility (as defined in Section 9 of the *National Greenhouse and Energy Reporting Act 2007* and National Greenhouse and Energy Reporting Regulations 2008) by fuel type, and the relevant requirements of the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*. GHG and NPI reporting records (or contemporary requirements at the time of the activities) will be complied with during the project for facilities where ConocoPhillips has operational control. A preventative maintenance system will be implemented, which includes regular inspections and maintenance of engines and key emission sources and emissions control equipment in accordance with the vendor specifications. The requirements of the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and Regulations 1995 will be met, specifically in relation to ODS.	Atmospheric emissions associated with the project will meet all regulatory source emission standards. Engineering design of the FPSO facility will seek to reduce atmospheric and GHG emissions through energy efficient design. Combustion engines and flaring equipment will be maintained according to vendor specifications to achieve optimal performance.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Light emissions	Marine reptiles. Birds.	Change in fauna movements and/or behaviour, such as the attraction or disorientation of individuals.	All vessels in Australian waters adhere to the navigation safety requirements contained within COLREGS, Chapter 5 of SOLAS, the *Navigation Act 2012* and subordinate Marine Order 30 (Prevention of Collisions) (as appropriate to vessel class) with respect to navigation and workplace safety equipment (including lighting). IALA Recommendation O-139 on The Marking of Man-Made Offshore Structures will be followed. External lighting on offshore facilities/infrastructure will be minimised to that required for navigation, safety and safety of deck operations, except in the case of an emergency. No pipeline installation activities will occur within the internesting BIA for olive ridley turtles at any time, including peak nesting and hatchling emergence periods. Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels: 1. identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs 2. update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP 3. combine the outputs from items 1 and 2 above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence 4. undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items 1, 2 and 3 above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP. As part of the development and implementation of the gas export pipeline installation EP, measures will be defined including no anchoring on shoals/banks, definition of speed limits that will be enforced during pipeline installation, and implementation of practical controls for key aspects (e.g. sedimentation/turbidity, underwater noise emissions and light emissions).	Light spill from the MODUs/drill ships, FPSO facility and project vessels will be limited to that required for safe operations and working requirements. No significant impacts to turtle populations from installation of the gas export pipeline.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Planned discharges	Physical environment – water quality and sediment quality. Shoals and banks. KEFs – shelf break and slope of the Arafura Shelf.	Localised and temporary reduction in water quality associated with increased turbidity, water temperature or salinity leading to impacts to marine fauna. Localised displacement, smothering (mainly associated with discharge of drill fluids and cuttings) or toxicity of benthic habitats/communities that are regionally widespread.	*General* All planned discharges from vessels will comply with relevant MARPOL 73/78 and Australian Marine Order requirements (as appropriate for vessel classification). All planned operational discharges will be managed in accordance with a project Waste Management Plan (and as detailed in activity-specific EPs). Pre-installation surveys will be undertaken to confirm the FPSO facility is not located in the vicinity of areas of seabed that are associated with the seafloor features/values of the shelf break and slope of the Arafura Shelf KEF (i.e. patch reefs and hard substrate pinnacles) and nearby shoals and banks (including Lynedoch Bank, Tassie Shoal and Evans Shoal, all > 27 km away). A maintenance program will be developed and implemented for the FPSO facility which includes inspection and maintenance of treatment systems to confirm discharge limits are met. All chemicals (hazardous and non-hazardous) used on the FPSO facility will undergo a HSE assessment and be approved prior to use. The HSE assessment required by the procedure aims to identify and control health and environmental risks during transport, use and storage of the chemicals. The procedure includes: • definition of key roles and responsibilities • the process for approvals and registration of chemicals • key requirements for safe transport, handling and storage. ConocoPhillips will confirm that the selection of chemical products within the planned discharge streams that are discharged to the marine environment are subject to a chemical assessment process. Products that meet at least one of the following environmental criteria are considered suitable by ConocoPhillips for use and controlled discharge to the marine environment is permitted: • rated as Gold or Silver under OCNS CHARM model • if not rated under the CHARM model, have an OCNS group rating of D or E (i.e. are considered inherently biodegradable and non-bioaccumulative). The use of products that do not meet these criteria will only be considered following assessment and approval through a chemical assessment process, as outlined above. The assessment will also be informed by an environmental risk assessment which will help ensure that any potential environmental impacts resulting from chemical use and discharge are minimised. *Drill fluids* No planned discharge of whole SBM will occur overboard. When using SBM, the solids control equipment will reduce the residual base fluid on cuttings content prior to discharge overboard. Residual base fluid on cuttings will be less than 10% by weight (w/w), averaged over all well sections drilled with SBM.	All planned operational discharges from the FPSO facility: • will not exceed the natural variation of existing baseline water quality conditions for temperature and hydrocarbons, and mercury or chlorine concentrations outside the Barossa offshore development area, and • will not impact areas of seabed that are associated with the seafloor features/values of KEFs or the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal (located > 27 km away from the Barossa offshore development area, which is beyond the outer boundary of planned operational discharges), and • meet relevant ANZECC/ARMCANZ and/or natural variation in ambient baseline conditions (where determined to be more relevant to the site-specific context to derive reference values) beyond the predicted mixing zone(s). Dewatering discharges will not extend beyond the Barossa offshore development area and will not impact areas of seabed that are associated with the seafloor features/values of KEFs or the nearest shoals/banks of Lynedoch Bank, Tassie Shoal or Evans Shoal.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			PW and cooling water An environmental monitoring program (**Section 7.2.3**) and adaptive management framework (**Section 7.3**) will be applied to manage PW and cooling water discharges. Mercury levels in PW discharge will be subject to monitoring during operations to confirm that concentrations remain within acceptable discharge limits. PW and cooling water will be discharged below the sea surface to maximise dispersion. Development of a predicted mixing zone(s) for PW and cooling water within the Operations EP, as informed by modelling and validation studies. During operations, verification monitoring and reporting of temperature and chlorine concentrations of the cooling water discharge stream and hydrocarbon concentrations of the PW discharge stream will be undertaken prior to discharge. Residual chlorine levels in the cooling water discharges will comply with a target of concentration of less than or equal to 3 ppm at the point of discharge to maintain safe operations. The temperature of the cooling water discharge plume from the FPSO will return to within 3 °C of the ambient temperature within 100 m of the discharge point. PW discharges will have a hydrocarbon content that is no greater than an average of 30 mg/L over any 24-hour period. The OIW concentration of PW will be continuously monitored by an installed OIW analyser which will be fitted with an alarm that activates if OIW concentration is > 30 mg/L. Baseline, periodic and 'for cause' (e.g. exceedance of contaminants) toxicity testing of PW discharges will be undertaken against the recognised ecotoxicity assessment methodology defined in ANZECC/ARMCANZ (2000). *Dewatering of flooding fluid* The location of the dewatering discharge will be selected to minimise impact on areas of regional environmental importance (e.g. shoals, banks, coral reefs, islands, etc.) to the extent practicable. Flooding fluid chemicals (e.g. biocide, oxygen scavengers and dye) will be selected for environmental performance (i.e. low toxicity chemicals), whilst maintaining technical performance requirements, and follow the chemical assessment process (as detailed above). The dewatering of flooding fluid will be detailed in the relevant activity-specific EPs developed during the detailed engineering and design studies for the project. The EPs will detail dewatering requirements, including definition of discharge characteristics (i.e. chemical additives and concentrations), discharge location and volumes, methodology and species thresholds. *MEG stream* The FPSO facility will have facilities that will regenerate and reclaim MEG for re-use or onshore disposal, if continuous MEG injection is used for flow assurance.	All discharges of SBM residual base fluid on cuttings from drilling activities will be below 10% w/w oil-on-cuttings averaged over all well sections drilled with SBM. Reduce impacts to the marine environment from planned discharges through the application of a chemical selection process, which includes an environment risk assessment.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			Wastewater and other planned discharges Oily bilge water from machinery space drainage is treated to a maximum concentration of 15 ppm OIW prior to discharge from vessels, as specified in MARPOL 73/78 (Annex I). Offshore discharge of sewage from vessels will be in accordance with MARPOL 73/78 (Annex IV) and Marine Order 96. Food wastes from vessels will be macerated to < 25 mm diameter prior to discharge, in accordance with MARPOL 73/78 (Annex V) and Marine Order 95. Detailed performance criteria for planned discharges will be defined in the activity-specific EPs.	
Waste management	Physical environment – water quality. Marine mammals. Marine reptiles.	Temporary and localised reduction in water quality, i.e. pollution or contamination of the marine environment. Interaction of marine fauna with solid wastes, such as plastic packaging, which may result in physical injury or mortality (through ingestion or entanglement) of the individual.	All wastes generated offshore will be managed in accordance with relevant legal requirements, including MARPOL 73/78 and Australian Marine Order requirements (as appropriate for vessel classification). A project Waste Management Plan will be developed and implemented, and will include details of: • the types of waste that will be generated by the project and will require containment, transport to, and disposal at, a licensed facility onshore • management protocols for the handling, segregation and responsible disposal of wastes. For example, non-hazardous and hazardous solid and liquid wastes will be transported safely to shore and disposed onshore at licensed treatment and disposal facilities. • measurable performance criteria • competency and training • audits, reporting and review, including compliance checks via waste manifests. Hydrocarbon and chemical storage and handling procedures will be implemented, including: • secure storage of bulk hydrocarbons and chemicals in areas with secondary containment • storage of hydrocarbon and chemical residues in appropriate containers • stocks of SOPEP spill response kits readily available to respond to deck spills of hazardous liquids and personnel trained to use them • planned maintenance system including maintenance of key equipment used to store and handle hydrocarbons/chemicals (e.g. bulk transfer hoses, bunding) • MSDS available on board for all hazardous substances. Non-hazardous and hazardous wastes will be managed, handled and stored in accordance with their MSDS, and tracked from source to their final destination at an appropriately licensed waste facility. Heavy lifting operations between vessels and the MODU/drill ship or FPSO facility will be undertaken using competent personnel and certified lifting equipment and accessories to minimise the risk of dropped objects.	Zero unplanned discharge of hazardous and non-hazardous wastes into the marine environment as a result of project activities. Hazardous waste will be transported onshore for treatment and/or disposal at licenced treatment and disposal facilities.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
Unplanned discharges	Physical environment– water quality and sediment quality. Shoals and banks. Tiwi Islands. Other offshore reefs and islands and NT/ WA mainland coastline. Marine mammals. Marine reptiles. Birds. Fish. Sharks and rays. Commercial fishing. Recreational and traditional fishing (Tiwi Islands)	Hydrocarbon/ chemical contact with shoals/ banks, reefs and islands at concentrations that result in adverse impacts. Alteration of biological communities as a result of the effects on key marine biota. Socio-economic impacts on commercial fishing, traditional fishing (Tiwi Islands) and tourism.	*General* The *OPGGS Act 2006* – Section 616 (2) Petroleum safety zones will be complied with, including establishment and maintenance of a petroleum safety zone around the well, offshore structure or equipment which prohibits vessels entering or being present within the specified area without written consent. Bunkering procedures will be implemented, which include: • use of bulk hoses that have dry break couplings, weak link break-away connections, vacuum breakers and floats • correct valve line-up • defined roles and responsibilities – bunkering to be undertaken by trained staff • visual inspection of hose prior to bunkering to confirm they are in good condition • testing emergency shutdown mechanism on the transfer pumps • assessment of weather/sea state • maintenance of radio contact with vessel during bunkering operations. Hydrocarbon and chemical storage and handling procedures appropriate to nature and scale of potential risk of accidental release will be implemented, which will include: • bulk hydrocarbons and chemicals stored in designated areas, with secondary containment • stocks of SOPEP spill response kits readily available onboard and personnel trained to use them • MSDS available on board for all hazardous substances. An Inspection Monitoring and Maintenance Program will be developed for the gas export pipeline to assess structural integrity and for any potential leaks. A SIMOPS procedure will be implemented to control and manage any concurrent SIMOPS activities.	Zero unplanned discharge of hydrocarbons or chemicals to the marine environment as a result of project activities. An activity-specific OPEP that demonstrates adequate arrangements for responding to and monitoring oil pollution in the event of a major unplanned release will be accepted by NOPSEMA prior to commencing the activity. An OSMP will be implemented in the event of a major unplanned release. The OSMP will include a number of operational monitoring plans and scientific monitoring plans to guide the spill response, and assess potential environmental impacts.

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			Long-term well blowout prevention All well design and control activities will be undertaken in accordance with a NOPSEMA approved WOMP and as detailed in activity-specific EPs. All drilling activities will be undertaken in accordance with accepted procedures that meet the requirements of the: • ConocoPhillips Well Construction and Intervention standard, which outlines minimum requirements (including testing and maintenance) for well control equipment (e.g. blowout preventer, casings/tubings and drilling mud systems) • ConocoPhillips Well Design and Delivery Process documentation including Well Engineering Basis of Design, Critical Well Review and Shallow Hazard Study • ConocoPhillips Wells Management System, which includes the requirement for a minimum of two barriers that are tested and maintained during all well operations. A MODU/drill ship Safety Case Revision will be developed and implemented, which describes the ConocoPhillips and MODU Operators agreed well control interface. *Vessels/facilities* The FPSO facility will be designed so that the hull shall be double-walled or double sided and compartmentalised condensate storage tanks. Vessel specific controls will align with MARPOL 73/78 and Australian Marine Orders (as appropriate for vessel classification), which includes managing spills aboard, emergency drills and waste management requirements. Vessel movements will comply with maritime standards such as COLREGS and Chapter V of SOLAS. Offtake vessels will be piloted during berthing and offloading operations. Visual monitoring of the offloading manifold and hose will be maintained during offtake operations to allow for rapid emergency shut down. All marine contracted vessels will undergo the ConocoPhillips Global Marine vetting process, which involves inspection, audit and a review assessment for acceptability for use, prior to working on the project. Vessel selection criteria will make considerations for designs and operations which reduce the likelihood of hydrocarbon spills to the marine environment as a result of a vessel collision. All vessels involved in the project will have a valid SOPEP or SMPEP (as appropriate for vessel classification).	

Aspect	Key factors	Potential impact for key factors	Key management controls	Environmental performance outcome
			Response measures (refer to **Section 7.2.2** for further discussion of emergency preparedness and response) Spill response in the event of a hydrocarbon or chemical spill will be implemented safely and be commensurate with the type, nature, scale and risks of the spill to key values and sensitivities, as defined in activity-specific OPEPs. A CMP will be implemented in the event of a spill, which includes: • emergency response planning • emergency management structure • incident notification • emergency response responsibilities and support providers. An OSMP will be initiated and implemented as appropriate to the nature and scale of the spill and the existing environment, as informed by a net environmental benefit assessment. ConocoPhillips will have additional contingency plans in place in the event of a well blowout, including side track relief well drilling, well capping and existing contracts with spill response agencies to facilitate efficient implementation of appropriate spill response measures.	
Decommissioning	Physical environment (seabed features and, water quality and underwater noise).	Physical damage and/ or disturbance to marine substrates and, benthic habitats and marine biota. Temporary and localised reduction in water quality.	Prior to the end of operating life, a decommissioning options study will be undertaken to inform the development of a Decommissioning EP that will be submitted to NOPSEMA. The Decommissioning EP will consider a range of decommissioning options (including those outlined in **Section 4.3.4**). The decommissioning options study will consider the merits of each option in the context of health, safety and environmental protection, technological feasibility, local capacity, regulatory compliance, public participation and economic stewardship within a broader ALARP framework to inform selection of the preferred decommissioning strategy. The ALARP framework will seek to minimise disturbance to marine habitats and will include justification for removing or leaving infrastructure on the seabed. The Decommissioning EP will be implemented for the duration of the decommissioning activities.	Decommissioning will not commence until a Decommissioning EP is accepted (by the regulator with jurisdiction for decommissioning at the time), to be informed by the outcomes of a decommissioning options study that considers ALARP and acceptability. The accepted Decommissioning EP will be consistent with any published Commonwealth Government policy or legislation prevailing at the time, as relevant to the environmental merit of removing or leaving infrastructure on the seabed upon abandonment and decommissioning of project facilities.

7.2 Implementation strategy

While a detailed outline of the implementation strategy is not required for an OPP, as this will be provided in subsequent activity-specific EPs, the following sections outline emergency preparedness and environmental monitoring that will be applied to manage environmental impacts and risks associated with the project, and assist in achieving the overarching project EPOs.

ConocoPhillips appreciates that, while a very low probability scenario, the effective planning and implementation in the event of a spill is taken seriously, and this firm commitment is reflected in this section.

7.2.1 Marine contract management

All marine contracted vessels will undergo the ConocoPhillips Global Marine vetting process prior to working on the project. The vetting process confirms that vessels meet or exceed the standards and criteria set by standard industry practice, international regulations, and relevant authorities such as NOPSEMA and AMSA. These requirements for vessel acceptance criteria include technical, personnel (e.g. crew competencies) and operational requirements for marine vessels engaged by ConocoPhillips.

Specific requirements of the vessel vetting process include:

- ConocoPhillips global standard that requires all vessels (including MODUs) used by ConocoPhillips to be vetted
- the vetting process is based on industry standards and best practices along with considerations of guidelines and recommendations form recognised industry organisations such as Oil Companies International Marine Forum and International Maritime Contractors Association, and international regulatory agencies like the International Maritime Organization and vessel Classification Societies
- requires a valid Offshore Vessel Inspection Database (OVID) report or Common Marine Inspection Document (CMID) report as required for vessel operation types
- for vessels where the OVID and/or CMID are not valid or available, a ConocoPhillips Approved Inspection Report is required.

The ConocoPhillips marine contracting strategy also implements the independent verification of the contractor's management system, leveraging the Oil Companies International Marine Forum's Offshore Vessel Management Self-Assessment program. This is key to ensuring that the contractor's safety management systems are implemented on their vessels and the crews are aware of their responsibilities and accountabilities.

The ConocoPhillips Marine function will maintain relationships with vessel owners and masters, and undertake quarterly face-to-face reviews for term contracts. The quarterly review topics will be safety, environmental, training schemes, the specific vessel performance, and the current/future scope of work.

7.2.2 Emergency preparedness and response

7.2.2.1 ConocoPhillips Crisis Management Plan

The CMP and OPEP will describe arrangements and reporting relationships for command, control and communications, together with interfaces to specialist response groups, statutory authorities and other external bodies.

The purpose of the ConocoPhillips CMP is to clearly define the framework and tools, such as the Incident Command System (ICS), that will facilitate the ability of organisations within the business unit to effectively respond to all incidents and interface with Government groups.

ConocoPhillips utilises the ICS as the system for emergency and crisis management. Team members are trained in specific roles and responsibilities and the processes and procedures of the ICS under the CMP guidelines. The development of an Incident Action Plan supports and guides the response actions for all emergency response events.

ConocoPhillips maintains a comprehensive Crisis and Emergency Management structure that is dependent on the nature and scale of the event that will be updated throughout the project life-cycle as appropriate, including the following:

- Crisis Management Team (CMT) – under the leadership of a Crisis Manager (CM). The CMT is responsible for the overall management of the incident from a strategic, legal, ethical and public image perspective.
- Incident Management Team (IMT) – under the leadership of an Incident Commander (IC). The IMT supports on-site operations, or in case of larger responses, assumes control of the response.
- Emergency Response Team (ERT) – onsite response teams under the control of the Emergency Commander (EC). The ERT is responsible for physically responding to and controlling emergency situations.

ConocoPhillips has a strategic approach to emergency response, providing a tiered structure of response that aligns with the levels of response outlined in the AMSA National Plan (2014). This tiered structure allows the IC to assess a situation and mobilise the appropriate level of response. Ongoing appraisal of the situation by the offshore and onshore emergency response team leaders allows the level of response to be upgraded or reduced in a controlled and effective manner.

The emergency response objectives are prioritised to manage:

- People: ensure the safety of all personnel
- Environment: protect the environment
- Asset: minimise the impact of damage to equipment and assets and provide technical support in the event of an emergency
- Reputation: management of legal and public image aspects including liaison with external agencies and authorities
- Livelihood: minimise disruption to workplace activities.

Contractors must, where required, comply with ConocoPhillips' Emergency Response Plans and Procedures. For this project context, Emergency Response Plans for any MODU/drill ship or vessel contractors will be updated to align with the company requirements, outlining the agreed interfaces between ConocoPhillips and the contractor. In the event of impending adverse weather or other conditions, the contractor must have a procedure in place to implement, in consultation with ConocoPhillips, the appropriate precautionary measures to safeguard personnel, property and environment.

7.2.2.2 Oil pollution emergencies

First Strike Plan and OPEP

In the unlikely event that there is a significant hydrocarbon release associated with the project, a First Strike Plan will be implemented. The First Strike Plan will be incorporated into the OPEP and provides guidance on the immediate actions required to commence a response. The MODU/drill ship, FPSO facility and support vessels will have SOPEPs and SMPEPs in accordance with the requirements of MARPOL 73/78 Annex I (as appropriate to vessel class). These plans outline responsibilities, specify procedures and identify resources available in the event of a hydrocarbon or chemical spill from vessel activities. The First Strike Plan is intended to work in conjunction with the SOPEPs/SMPEPs, if hydrocarbons are released to the marine environment from a vessel.

The OPEP provides the framework and information required for an effective response in the unlikely event of an unplanned release of hydrocarbon from project activities. The OPEP details actions to be taken in response to the incident, describes arrangements and reporting relationships for command, control and communication, and provides interfaces to emergency specialist response groups, statutory authorities and other external bodies. Proactive and early engagement with each company or agency that may be involved in the response activities will be undertaken to ensure that the role of each agency is agreed and clearly defined in the OPEP.

ConocoPhillips' response objectives are to develop and implement appropriate and effective response strategies commensurate to the scale, nature and risk of the spill. The OPEP will include detailed response strategies and hydrocarbon pollution emergency response arrangements, as informed by the maximum credible hydrocarbon spill scenarios identified for the specific activity. The response strategies that may be implemented include monitor and evaluate, wildlife response (e.g. hazing, pre-emptive capture, post-contact responses), physical dispersion, chemical dispersion, containment and recovery, protection and deflection, and shoreline clean-up. The suitability of the response strategies will be evaluated in the OPEP and include a net environmental benefit impact assessment (NEBA) and ALARP assessment. The objective of the NEBA process is to identify the potential net environmental benefit (positive impacts) or net environmental detriment (negative impacts) to key sensitive receptors associated with the implementation of particular spill response strategies. The process allows direct comparison of response strategies, and identifies potential impacts of these relative to the unmitigated impacts of the spill on sensitive receptors. It also allows assessment of the value of implementing multiple response strategies.

Through development of the Barossa appraisal drilling EP in 2016/2017, ConocoPhillips has defined a robust and tailored spill response strategy in the unlikely event of a large-scale hydrocarbon release. The response strategy was informed by the following process:

- an activity-specific spill response workshop – attended by a specialist team of marine and environmental scientists together with senior ConocoPhillips spill response personnel and Australian Marine Oil Spill Centre (AMOSC) personnel
- a pre-spill NEBA – identification of sensitive receptors that may be affected (as informed by stochastic modelling) and assessment of response options available
- an ALARP assessment – evaluation of ALARP considerations such as health and safety, practicability, feasibility, flexibility. For example: safe operation of response vessels in areas where there may be gas plumes; limited effectiveness of techniques for highly volatile, rapidly evaporating spills; time required to mobilise the response; application of chemical dispersants increasing entrained and dissolved hydrocarbons where it could impact on submerged sensitive receptors and weather slower; and logistical challenges such as flight times and refuelling requirements
- geographic/environmental conditions – remote, offshore environment, wave heights, wind etc
- fate and weathering characteristics of the spill, e.g. highly, volatile marine diesel or condensate versus persistent HFO or IFO-180 **(Section 6.4.10.4**)
- assessment of the potential impacts and risks to the environment from the implementation of the response strategy in the context of whether it will realise a net environmental benefit.

Applying this process facilitates the implementation of tailored spill response strategies that are appropriate and suitable to the nature and scale of the spill (e.g. volume released, hydrocarbon type etc.). In general, the monitor and evaluate response strategy would likely be initiated in the event of a large-scale release. This strategy provides situational awareness which is critical to the implementation of a coordinated, focused and effective spill response. A range of additional response strategies, such as physical dispersion, chemical dispersion, containment and recovery, protection and deflection, wildlife response and shoreline clean-up, may also be implemented under specific circumstances, if determined to be suitable (e.g. pass the pre-spill NEBA, ALARP and acceptability assessments).

During the development of activity-specific EPs, a similar process to that outlined above will be followed to identify and evaluate the spill response strategies relevant to the spill scenarios for each activity. This will subsequently inform the content of the activity-specific EPs, OPEPs and First Strike Plans, including the evaluation of impacts and risks from implementing the different response strategies.

OSMP

The ConocoPhillips OSMP will include a number of operational monitoring plans and scientific monitoring plans for implementation following a large-scale hydrocarbon spill incident, used to guide the spill response and assess potential environmental impacts. The OSMP will include an implementation plan together with individual operational and scientific monitoring plans.

The overarching objective of the OSMP is to provide monitoring plans that:

- provide the overarching structure for operational monitoring to support situational awareness, to define the adverse exposure zone and inform spill response strategies to reduce risks of the spill to ALARP
- inform a practical scientific monitoring process that can be implemented in the event of a spill to allow scientifically robust investigation of the extent and impacts of the spill over the short and long-term.

ConocoPhillips has a number of existing contracts, master service agreements, and business support relationships and alliances with service providers in place to provide support in the event of a spill. These will be reviewed, updated and revised to ensure they enable delivery of the OSMP for the duration of the project.

7.2.2.3 Emergency and spill response drills, exercises and audits

As required by Regulation 14 (8A) of the OPGGS (E) Regulations, ConocoPhillips will test the activity-specific OPEPs in order to confirm response readiness. OPEPs will be developed in line with the overarching ConocoPhillips documentation and plans, with testing of the OPEP including either desktop and/or field-based spill response drills, exercises and audits.

7.2.3 Environmental monitoring

This section provides an outline of the environmental monitoring framework for the project. This framework will be further developed prior to initiation of the key development phases as part of activity-specific EPs, and will be updated throughout the project life-cycle as appropriate.

As described previously in **Section 2**, the HSEMS provides the framework that ConocoPhillips uses to integrate commitments into its daily business and operations and upon which environmental performance outcomes (EPOs) are based. All elements of the HSEMS are integrated into this OPP to support environmental management throughout the project.

Monitoring will be implemented in order to demonstrate compliance with regulatory limits and ConocoPhillips' project requirements established in this OPP. Monitoring will also provide verification of the overall design and effectiveness of the implemented control measures. The key objectives of the proposed monitoring activities are as follows:

- to monitor discharges and emissions to ensure compliance with relevant legislation, standards and ConocoPhillips' environmental objectives for the project
- to determine whether environmental changes are attributable to the project activities, other activities or as a result of natural variation
- to enable reliable data to inform an appropriate corrective course of action if required
- to provide a basis for continuous review and improvement to the management and monitoring arrangements over the project life-cycle, and adaptive management as appropriate.

Forward management and monitoring framework in activity-specific EPs

While this outline framework is presented at this early stage OPP, there is a clear forward process where specific details will be subject to review and approval, under activity-specific EPs. It is at that stage where final details of specific activities, and an appropriate management, monitoring and reporting program, is tailored to meet ALARP and acceptable outcomes specific to that stage of development at the time. The legislative framework for this forward process is described further below.

Under the OPGGS (E) Regulations, it is a legislative requirement for a titleholder to submit an EP before commencing an activity and the activity cannot take place until the regulator accepts the EP. The EP must be appropriate for the nature and scale of the activity and describe the activity, the existing environment, details of environmental impacts and risks and the control measures for the activity. In addition, the EP must include an implementation strategy to demonstrate that the impacts and risks will be acceptable and reduced to ALARP, and to describe how appropriate EPOs, standards and measurement criteria outlined in the EP will be met.

Subsequent to this OPP, a series of EPs will be developed to cover the project activities at the following key stages of the project (including development drilling, subsea structure installation (including gas export pipeline installation); tow-out and hook up of the FPSO facility; gas export pipeline installation; pre-commissioning; commissioning; operations; decommissioning). Each EP will outline specific strategies to avoid, mitigate or reduce potential environmental impacts. The EPs will be used to inform personnel of the monitoring, auditing, reporting and corrective action requirements. The EPs will also identify the roles and responsibilities of key individuals/positions to implement the commitments for environmental management and monitoring.

The results of the comprehensive baseline monitoring program undertaken for the project, as summarised in **Section 5**, will provide a reference for subsequent environmental monitoring.

While specific environmental monitoring commitments are yet to be fully defined at this early stage of OPP assessment, a summary of key considerations for key discharges is provided further in the following sub-sections.

Planned marine discharges

Considering the nature and scale of the planned marine discharges during operations, the PW and cooling water discharges from the FPSO facility will provide the primary focus of the monitoring framework during operations.

The framework will ensure the nature, extent, and potential effect of planned discharges are assessed, and help determine changes to water quality, sediment quality and benthic habitats over time.

In summary, the monitoring program would comprise:

- in-line monitoring of discharges from the FPSO facility
- monitoring of the environment, including receiving waters, sediment quality sampling and assessment of benthic habitats, that may be influenced by project activities
- a sampling frequency at an appropriate time scale (to be determined during EP development) for comprehensive survey of the environment in the Barossa offshore development area that may be influenced by project activities
- Whole-of-effluent toxicity (WET) testing to inform Direct Toxicity Assessment (DTA) of the PW
- ongoing monitoring of in-line PW and cooling water and verification against dispersion models.

The framework for planned marine discharges is outlined further in **Table 7-2** below. Trigger actions will be developed to support implementation of the monitoring framework and used to inform and refine the monitoring parameters.

Environmental monitoring that would be triggered in the unlikely scenario of an unplanned discharge as previously outlined in **Section 7.2.2**.

Table 7-2: Summary of planned discharge monitoring framework

Monitoring program	Objectives	Indicative frequency

FPSO facility monitoring	• To monitor discharges of PW and cooling water from the FPSO facility, combined with modelling, to verify that concentrations meet relevant ANZECC/ARMCANZ guidelines and/or natural variation in ambient baseline conditions (where determined to be more relevant to the site-specific context to derive reference values) beyond the predicted mixing zone(s).	• Continuous:
		  • PW and cooling water – discharge volume (online flow meter)
		  • TPH (online OIW analyser).
		• Daily:
		  • PW – TPH, discharge volumes.
		• Annually
		  • PW – characterisation (samples collected on FPSO facility and analysed)
		  • Cooling water – chlorine concentration and temperature.
		• Additional monitoring as a result of trigger actions.

Environment monitoring (water quality, sediment and benthic habitats)	• To establish baseline levels of contaminants and conditions in the Barossa offshore development area for future comparisons during operations and decommissioning. • To monitor the environment in the area influenced by project activities (as informed by modelling and FPSO monitoring) and equipment/ infrastructure in the Barossa offshore development area.	• Baseline (prior to activity) – will include impact and reference sites. • Periodic environment monitoring program in the Barossa offshore development area (as informed by the FPSO facility monitoring). • Additional field sampling as a result of trigger actions or water quality and/or sediment assessments.

Monitoring program	Objectives	Frequency
WET testing	• To characterise operational PW discharges and inform triggers that are appropriate for the sensitivity of local organisms.	• Post start up (once conditions are stable, expected approximately 3 to 6 months from start-up) (multi species test, indicatively eight species). • Nominally quarterly monitoring of in-line discharge stream for the first two years of operations (indicatively three species surrogate WET test). • Nominally five yearly after the first two years of operations (multi species test, indicatively eight species), subject to review of changes in the nature of discharge over time. • Additional WET testing as a result of trigger actions or chemical changes.

Atmospheric emissions

Atmospheric emissions will be monitored and reported for the project, in accordance with the contemporary policy position and regulatory requirements at the time. The framework is outlined further in **Table 7-3** below.

Table 7-3: Summary of air emissions monitoring framework

Monitoring program	Objectives	Frequency
GHG emissions (e.g. from flaring, venting, fuel gas and diesel combustion, acid gas removal and fugitive emissions)	• Recording and reporting of emissions as required by the *National Greenhouse and Energy Reporting Act 2007* and the Safeguard Mechanism (or contemporary requirements at the time).	• Ongoing
Criteria pollutant emissions (e.g. from flaring, fuel gas and diesel combustion, acid gas removal and fugitive emissions)	• Recording and reporting of emissions as required by the National Pollutant Inventory (or contemporary requirements at the time).	• Ongoing

Gas export pipeline

The results of the preliminary pipeline survey effort have been used to characterise the gas export pipeline corridor as summarised in this OPP.

ConocoPhillips will undertake a further pipeline route survey effort to inform route optimisation and reduce environmental impact. It is expected that targeted studies will include a characterisation of the baseline conditions for sediment and water quality and benthic habitats along the selected pipeline route, with particular focus on nearby shoals/banks or subtidal features.

Installation schedule of the gas export pipeline will take into consideration seasonal presence/activity of marine turtles to prevent significant adverse impacts during peak seasonal internesting period for flatback (June to September) and olive ridley (April to August) turtles in proximity to the Tiwi Islands. Should pipeline installation activities be required to be undertaken during this period, within proximity (60 km) of the Tiwi Islands, the following process will be undertaken to identify how the pipeline will be installed to reduce impacts to ALARP and acceptable levels:

- identify the pipeline installation methods that can achieve the technical requirements of the project and use this to define the operational area within which all pipeline installation activities will be undertaken and within which all environmental impacts and risks relating to pipeline installation will be assessed and managed to achieve the EPOs
- update of latest knowledge on marine turtle density and seasonal movements within the internesting habitat critical to the survival of flatback and olive ridley turtles, drawing on latest literature, any field observations from future pipeline survey work and advice from discipline experts – building on the information presented in this OPP
- combine the outputs from items above with understanding of the existing environment to identify key environmental values/sensitivities at risk from pipeline installation activities with consideration of any seasonal presence
- undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from items above to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP. Note: if required, additional controls and/or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP.

If trenching/dredging activities for the gas export pipeline installation are required, i.e. if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, they will occur outside the peak flatback (June to September) and olive ridley (April to August) turtle internesting period. The following process will be used to identify how the pipeline in the section to be trenched/ dredged will be installed to reduce impacts and risks to ALARP and acceptable levels:

- undertake numerical modelling to predict the extent, intensity and persistence of sediment plumes arising from trenching/dredging activity
- use the outputs of the numerical modelling to identify key environmental values/sensitivities at risk from trenching/dredging activities with consideration of background/baseline conditions and any seasonal presence
- update of latest knowledge of how aspects arising from trenching/dredging activities can impact the marine environment, including marine turtles and benthic communities
- undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from the items above with the understanding of the environment (e.g. benthic habitat maps) to evaluate the environmental impacts and risks and verify the impact assessment conclusions are consistent with those presented in this OPP, i.e. confirm impacts from trenching/dredging will be temporary and localised. Note: if required, additional controls and/ or mitigation measures will be identified to demonstrate consistency with the impact assessment presented in this OPP.
- develop a dredge management plan that:
    - details how trenching/dredging will be undertaken (which will be informed by the information derived from items above)
    - identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels
    - includes an adaptive management strategy for how trenching/dredging activity will be managed, including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised

If use of an anchored pipelay vessel is required, i.e. it may only be required if the pipeline has to remain outside the Oceanic Shoals marine park in the shallow water area of the pipeline corridor, the following process will be used to identify how anchored pipelay installation will be undertaken to reduce impacts and risks to ALARP and acceptable levels:

- use the information and data derived from the pre-lay survey of the gas export pipeline installation route to update understanding of the existing environment along the gas export pipeline route
- identify any anchor restrictions zones, i.e. areas where anchors cannot be placed, e.g. shoals, banks or coral outcrops
- define how installation of the pipeline would be undertaken including start-up anchor pattern, operational anchor pattern and lay down (ending) anchor pattern, and predict the number of anchor drops required
- undertake an additional impact assessment that builds on the assessment presented in this OPP and incorporates the information from the items above, with consideration of any seasonal presence, to evaluate the environmental impacts and risks and to verify the impact assessment conclusions are consistent with those presented in this OPP (Note: if required, additional controls and/or mitigation measures will be identified to be implemented to demonstrate consistency with the impact assessment presented in this OPP)
- develop a pipeline lay anchoring management plan that:
    - identifies how pipelay installation would be undertaken using an anchored pipelay vessel
    - identifies the control and mitigations measures, environmental performance outcomes, environmental performance standards and measurement criteria that demonstrate the environmental impacts and risks can be reduced to ALARP and acceptable levels
    - includes an adaptive management strategy for how anchoring activity will be managed including what information and/or data will be used to provide early warning of adverse trends and trigger adaptive management before environmental performance outcomes are compromised.

During operation of the pipeline, an Inspection Monitoring and Maintenance Program will be developed and implemented for the gas export pipeline. As part of this program, visual inspection of benthic habitats in the immediate vicinity of the pipeline may be undertaken, should the final selected easement be close to relevant shoals/banks of interest.

Decommissioning

Considering that the project is in the early design phase, and given the expected operating life of the project is approximately 25 years, the activity-specific decommissioning EP will provide detailed information and descriptions of the nature and scale of the activity, potential environmental impacts and risks, and the control measures that will be implemented. The monitoring framework will be tailored to the decommissioning strategy to be implemented at the time, and expected to include a program of monitoring seabed sediment quality, water quality and benthic habitats pre-and post-decommissioning.

7.3 Adaptive environmental management

An adaptive environmental management framework will be implemented throughout the life of the project and tailored as the project 'life-cycle' progresses (**Figure 7-1**). The environmental management framework will provide overarching governance for the measurement, monitoring and response to environmental aspects associated with the project. The ConocoPhillips HSEMS, particularly Elements 13 to 15, provides the basis to achieve effective implementation and integration of the adaptive management framework. The framework will also align with the principles of ESD and provide a mechanism for adaptive management over time.

Adaptive management is a circular or iterative process that allows past information to feed back into and improve management responses and strategies. This continual monitoring and evaluation process assists in the active adaptation of management and improvement through a learning process. It requires transparent planning systems and implementation strategies, and a strong emphasis on monitoring and reviewing to ensure emerging information is reflected in future planning.

The adaptive management framework will be suitable to the nature and scale of the project, as addressed in the activity-specific EPs, and reflect the key regionally important environmental values. Implementation of an adaptive management framework will determine whether the management measures applied are relevant and effective on a continuous basis. The framework will provide an appropriate means to confirm that project-related effects on environmental values and sensitivities are managed to an acceptable level and that environmental performance outcomes are being achieved.

The framework will inform management decisions and enable flexibility to adapt the approach over time to take into consideration any changes to the existing marine environment or environmental legislation (e.g. listing of new EPBC species, finalisation of the AMP management plans), new technologies and new information (e.g. scientific understanding or engineering).

ConocoPhillips' adaptive management framework consists of the following key steps:

- *Assess and define*: assess the context of the project and define management measures to ensure that impacts will be managed to an acceptable level
- *Plan*: develop a monitoring plan/strategy which defines appropriate outcomes and performance indicators (e.g. targets and triggers)
- *Implement and monitor*: implement the monitoring plan/strategy and monitor performance against the outcomes and performance indicators
- *Evaluate*: review monitoring results to understand the effectiveness of the management measures and determine if improvements can be made. Key findings from the evaluation process will be reported and recommendations made. Audits undertaken during the project will also feed into this step
- *Adjust and adapt*: feed any recommendations and key learnings back into the monitoring plan/strategy (Step 3) to allow tailoring of the approach and facilitate continuous improvement. The overall adaptive management framework will be periodically reviewed.

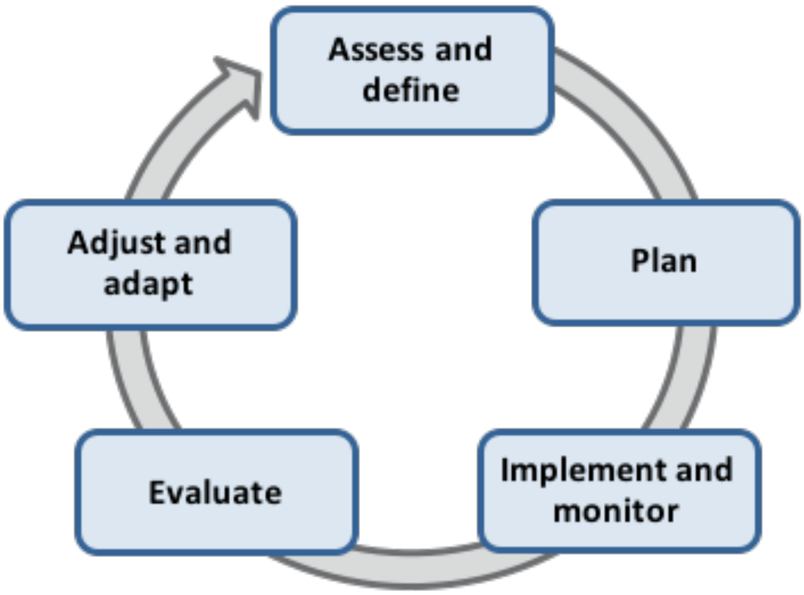


Figure 7-1: Adaptive management framework

7.4 Overall statement of acceptability

Overall, ConocoPhillips considers the project to be acceptable, as informed by a risk-based assessment, taking into account that:

- the remote project location of the Barossa offshore development area, which is predominantly located in deep, open offshore waters, means no facilities will be placed near any areas of regional environmental importance such as shoals, banks, coral reefs or biologically important areas for marine fauna (**Section 4**)
- planned operations have a relatively limited extent (**Section 4**), with the impacts and risks considered low (**Section 6**)
- the risks of unplanned releases is medium, however the likelihood is remote given comprehensive management controls will be implemented (**Section 6**)
- the implementation of key management controls and clear definition of appropriate and measurable EPOs that will assist in managing all environmental aspects of the project (**Section 7**)
- the project will be undertaken in accordance with relevant legislation, standards and industry guidelines, consistent with the principles of ESD (**Section 7.5**) and ConocoPhillips expectations for responsible environmental management (**Section 2** and **Section 3**).

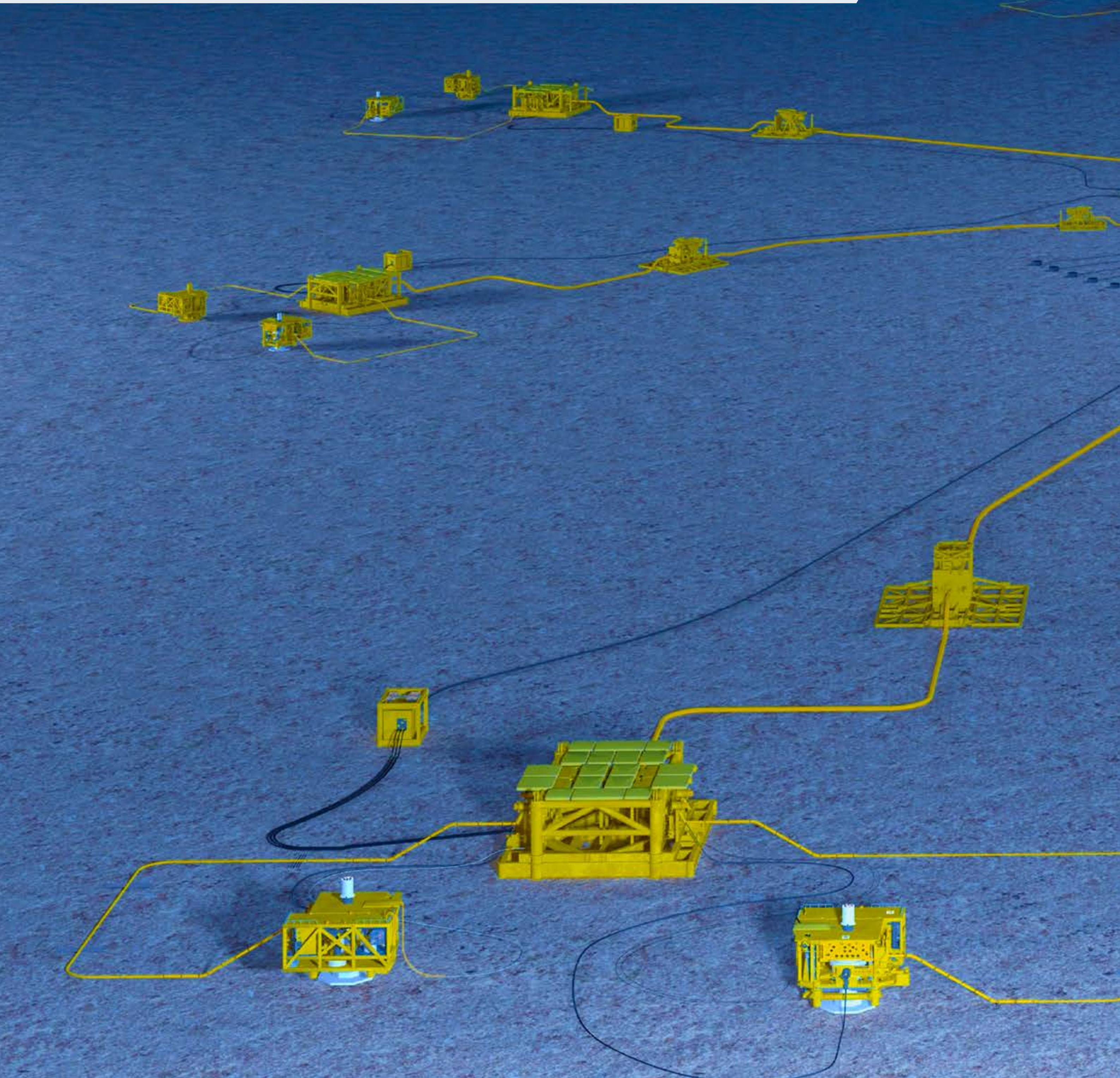
7.5 Overall statement of consistency with principles of ecologically sustainable development

ConocoPhillips considers the project to be consistent with the principles of ESD, as summarised in **Table 7-4**.

Table 7-4: Summary of project alignment with the principles of ESD

Principles of ESD (as defined in Section 3A of the EPBC Act)	Project alignment
Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	The assessment presented within this OPP relates to the entire life-cycle of the project, and therefore takes into account both short-term and long-term considerations and potential impacts associated with the project. Specifically, alignment of the project with this principle is shown through the following: • The ConocoPhillips Sustainable Development Risk Management Practice and the ConocoPhillips HSE and Social Issues Due Diligence Standard provide an integrated evaluation of environmental, social and economic issues to be carried into project reviews, design, execution and operation. • The end product of this project (including high quality, clean natural gas with lower net emissions than other fossil fuels) is a transitional fuel to meet regional and global demand for energy in a sustainable framework, with significant contribution to Government taxation revenue, creation of employment opportunities and economic growth.
If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (i.e. the precautionary principle).	A comprehensive environmental risk assessment of all impacts and risks associated with the project has been undertaken within this OPP (Section 6) and key management controls defined as relevant to the nature and scale of the potential impacts/risks. The assessment has acknowledged any specific areas where there may be some level of uncertainty (i.e. confidence), and this has been taken into account when defining the potential impacts and risks and residual risk rating. The assessment has been informed by an extensive scientifically robust marine baseline studies program and understanding of the marine environment within the project's area of influence (**Section 5**). ConocoPhillips' commitment to comprehensive environmental studies has also contributed substantially to the scientific fabric of the region, providing wider benefits in increasing the knowledge base of the area. The assessment has also been informed by modelling, which has a number of levels of conservatism built in to take into account uncertainty in final project design.
The principle of inter generational equity: that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The key management controls and EPOs, as presented in **Table 7-1**, have been defined with consideration of this principle.
The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.	The conservation of biological diversity and overall ecosystem integrity has been considered in the environmental risk assessment (**Section 6**), and has been informed by a detailed understanding of the existing marine environment (**Section 5**) within the project area. The key management controls and EPOs (**Table 7-1**) have also been defined with consideration of this principle.
Improved valuation, pricing and incentive mechanisms should be promoted.	The key management controls, including the overarching ConocoPhillips HSEMS and CPMS, (**Table 7-1**) seek to align with this principle, where practicable.

8 Consultation



Section 8 summary

Purpose:

This section describes the consultation that has occurred as part of this OPP, both during its development and during the public comment period, and the future consultation that will occur for the project.

Section at a glance:

Previous consultation: ConocoPhillips has been a titleholder and operator of the exploration, appraisal and development activities supporting the project since 2004. Engagement in recent years has included the plans to develop the project area as a potential future backfill gas supply for the Darwin LNG facility.

Based on its history of proactive consultation, ConocoPhillips believes stakeholders support development of the Barossa offshore development area and the continued economic benefit it will deliver to Australia, in particular Darwin and the NT, and understand that a new gas resource will be required for the DLNG facility once the Bayu-Undan Field is depleted.

Public comment period: The public was invited to submit their comments on the project to NOPSEMA for consideration during an eight-week public comment period. The Barossa OPP public comment period was publicly advertised and communicated directly to stakeholders by ConocoPhillips. The full OPP and appendices, along with information on how to make a submission, were also made available on NOPSEMA and ConocoPhillips' websites.

A total of seven (7) submissions were received during the OPP public comment period. A summary of these comments, a merit assessment of the items raised, and ConocoPhillips' response to them is included in this OPP (**Appendix R**). Any changes made to the OPP as a result of these comments are also identified.

NOPSEMA's Guidance Note clarifies that an objection or claim does not have to be accommodated through changes to the project, but the proponent must assess whether any changes put forward are practicable or feasible, particularly in reducing impacts and risks.

Future consultation: Subject to acceptance of the Barossa OPP by NOPSEMA, ConocoPhillips will commence preparation of Environment Plans (EPs) for project activities. The preparation and assessment of specific EPs for each activity will involve further detailed stakeholder consultation prior to their submittal to NOPSEMA for assessment.

The consultation process for EPs is designed to align with NOPSEMA's published consultation guidance as well as comply with all relevant regulatory requirements.

Consultation will occur during preparation of each EP to further understand and seek feedback on the key issues and concerns of relevant stakeholders, with the outcomes fully documented in the EPs submitted to NOPSEMA. Following this, ConocoPhillips will continue ongoing, targeted consultation with stakeholders with direct interest in the activities. ConocoPhillips has dedicated channels for enquiries and ongoing communication with the public.

ConocoPhillips also consults on a regular basis with scientific and academic stakeholders to better understand the environment in which it operates and to explore areas for collaboration and research related to its offshore permits. During the project, ConocoPhillips will continue to seek similar opportunities to share and advance knowledge with other stakeholders.

8 Consultation

8.1 Overview

ConocoPhillips understands the importance of thorough, meaningful and ongoing consultation with stakeholders as part of its social licence to operate and fulfilment of regulatory commitments. Consultation supporting the project is an integral and ongoing component of all business activities related to the Company's exploration, appraisal and development activities for its Bonaparte Basin acreage.

ConocoPhillips believes early and sustaining engagement is key to achieving mutual productive outcomes for both the Company and stakeholders as it assists the Company to understand potential issues and develop solutions.

ConocoPhillips believes its previous and continued efforts to share and explain its intentions for the project meet the intent of early, proactive engagement with relevant stakeholders which informed the consideration of the information in this OPP.

ConocoPhillips has been a titleholder and operator of the exploration, appraisal and development activities supporting the project since 2004 and has developed good relationships with a broad range of stakeholders, including the Commonwealth and NT Governments, commercial fishing associations, scientific and educational organisations (including recognised experts), spill response agencies, local business associations, other oil and gas industry operators, contractors, non-government organisations and co-venturers.

This history of consultation has demonstrated to ConocoPhillips that the majority of stakeholders relevant to the project understand and support the Company's long-term intentions and requirements.

8.2 Approach and objectives

ConocoPhillips' stakeholder engagement activities are an integral part of our sustainable development commitment to be transparent and accountable. ConocoPhillips consults openly with stakeholders about upcoming activities and potential development of the fields within our offshore permits to understand their expectations of the Company and considers these opinions in the development of business plans and actions.

This process fosters an environment of trust and mutual respect. The approach is embedded in our SPIRIT Value of integrity, which states that we will be ethical and trustworthy in our relationships with stakeholders. ConocoPhillips' 'Principles for Effective Non-Financial Stakeholder Engagement' provide corporate guidance and expectations and commit ConocoPhillips to:

- proactively identifying and engaging with key stakeholders at an early stage
- including key stakeholders in the design and implementation of the engagement process
- listening in order to understand stakeholders' interests, concerns and culture
- communicating openly and transparently
- seeking solutions that create mutually beneficial business and engagement approaches and build long-term value for both the Company and our stakeholders
- following through on our commitments and being accountable for the results, both internally and externally.

This approach is implemented through the Company's stakeholder management standards, systems and practices and reflective of approaches commonly adopted by the oil and gas industry, within Australia and internationally. More specifically, it aligns with NOPSEMA consultation guidelines under the OPGGS (E) Regulations 2009. The key sources of guidance for stakeholder engagement used by ConocoPhillips are summarised in **Table 8-1**. The internal project Stakeholder Engagement Plan reflects this guidance and provides strategic direction to meet the following objectives:

- inform relevant stakeholders of the objectives and rationale for the development options for the project
- explain how ConocoPhillips will identify and mitigate potential risks that may impact relevant or affected persons/organisations
- listen to and address any concerns arising before, during and after regulatory approval and understand requirements for ongoing consultation.

Table 8-1: Stakeholder engagement guidance sources

Stakeholder	Guidance
Internal	• Corporate Principles for Stakeholder Engagement • Corporate Stakeholder Engagement Action Plan
External	• Australian regulatory agencies (legislation and guidelines) – NOPSEMA, NT Department of Mines and Energy (DME), Fisheries Division of NT Department of Primary Industry and Resources (DPIR), Australian Fisheries Management Authority (AFMA), NT Environment Protection Authority (NT EPA) • Australian industry organisations (principles and methodology) – APPEA • International organisations (guidelines) – International Petroleum Industry Environmental Conservation Association (IPIECA), American Petroleum Institute (API), International Finance Corporation (IFC), International Association for Public Participation (IAPP)

8.3 Identification and classification

Stakeholder consultation supporting the project has drawn on a range of information sources to identify relevant stakeholders' functions, activities and interests. The list of stakeholders and issues is dynamic and changes as consultation and understanding builds and priorities and opinions evolve.

The sources and methods ConocoPhillips have used to date include:

- a detailed stakeholder identification and mapping project to classify more than 400 individuals/organisations and consider their known viewpoints and potential issues that could be of relevance to future development of the Barossa offshore development area
- stakeholder categorisation and definition of stakeholder groups, in broad alignment with those used by NOPSEMA to facilitate consistency with regulatory requirements
- analysis of stakeholder groups to assist in identifying and prioritising key stakeholders, and understand how to best engage with these groups
- stakeholder identification, classification and consultation records associated with progressing environmental approvals and conducting exploration activities within the Barossa Field since 2004, with particular reference to other marine users of the Barossa offshore development area and its surrounds
- records of stakeholder consultation with the Australian, NT and WA governments on future development options for the Barossa Field since 2014
- ConocoPhillips' history of consultation and established relationships with the Darwin and wider NT communities as operator of the Bayu-Undan Field in the Timor Sea and the DLNG facility
- ConocoPhillips' history of consultation and engagement with stakeholders during all exploration and appraisal activities undertaken offshore northern Australia, including within the Barossa and Caldita permit in the Bonaparte Basin.

The initial detailed stakeholder mapping completed in 2011 used a combination of desktop research and internal workshops, combined with previous experience from working with some of the groups concerned. The outcomes of the mapping project provided detailed analysis of each stakeholder group, identified key personnel and "known" levels of interest and support at that time. The mapping has been informed by, and updated using, information gained during subsequent stakeholder engagement on activities undertaken within the Bonaparte Basin acreage.

Issues, risks and opportunities associated with the project were mapped to stakeholders' interests. Potential non-environmental and socio-economic considerations of offshore development on local communities were also examined. To ensure consistency with regulatory requirements, ConocoPhillips adapted its categorisation and definition of stakeholder groups to broadly align with those used by NOPSEMA, as outlined in **Table 8-2.**

Table 8-2: Broad list of stakeholder groups

Stakeholder group	Description
Commonwealth Government organisations	Commonwealth Government regulatory agencies, organisations and political representatives
NT Government organisations	NT Government regulatory agencies, organisations and political representatives
Foreign Governments and organisations	Foreign governments and organisations with an interest in the project
Associations	Petroleum and professional and recreational fisherman industry associations
Industry	Petroleum titleholders (current and future applicants)
Other marine users	Commercial and recreational fishermen, shipping companies
Environmental interest groups	Environmental non-government organisations
Darwin Harbour users	Darwin Ports, Darwin Harbour commercial and recreational users
Traditional Owners and Indigenous groups	Traditional Owners and other local Indigenous groups
Business community	Suppliers of goods and services, including those based in the NT or providing services in the NT
Local employees	Employees living and/or working in the NT
Research/education groups	Interested research, education and training organisations
Other community stakeholders	Other interested groups and/or individuals

Stakeholder mapping provides an evolving assessment of stakeholder sentiment and is reviewed and refined as the project progresses to further understand and characterise the key relevant stakeholders. The mapping has helped guide ConocoPhillips' subsequent stakeholder consultation informing environmental permitting, appraisal activities and baseline environmental marine studies – all feeding into the understanding of issues and opportunities consolidated into this OPP assessment.

In preparing the Barossa OPP, ConocoPhillips used this information and method to design a consultation program across five stakeholder groups. Examples of stakeholders within each group and the roles they have played in helping guide activities to this date are outlined in **Table 8-3**.

While these groups have formed the basis of an ongoing proactive consultation program by ConocoPhillips, all members of the public have also had the opportunity to seek further information and provide their views during the OPP public comment period. ConocoPhillips will also maintain public information channels throughout the project.

The OPP public comment period has provided ConocoPhillips the opportunity to share more detail and build on its understanding of the relevant and interested stakeholders for the project, their areas of interest and views on the future potential development.

Table 8-3: OPP specific stakeholder consultation groups

Group	Role
Expert advisory Technical experts, including CWR, CDU, Monash University, AIMS and the Fisheries Division of the NT DPIR.	• Assist in understanding of environmental values and sensitivities, including validation of certainty in scientific knowledge for key sensitive receptors such as marine mammals, marine reptiles, seabirds, fish, coral and benthic habitats. • Assist in validating potential risks and impacts.
Primary – community, government Key government agencies responsible for the assessment of onshore and offshore development proposals and other organisations potentially affected by these proposals (e.g. local governments, chambers of commerce, fishing operators).	• Assist in understanding of environmental values and sensitivities. • Assist in validating potential risks and impacts. • Help shape consultation requirements.
Secondary – government Australian, State and Territory Ministers, Members of Parliament and Senior Officers stakeholders whose activities and/or responsibilities may be relevant to a specific development concept.	• Assist in identifying potential risks and impacts. • Help understand community issues and requirements.
Wider – community All the above and other stakeholders previously engaged since 2004 as part of the appraisal activities within the Bonaparte Basin acreage. Includes stakeholders who may be affected by the development concept as well as those with a general interest in the project.	• Assist in understanding of environmental values and sensitivities. • Assist in identifying potential risks and impacts. • Help understand community issues and requirements.
Future (onshore) – community Additional stakeholders who may be affected by elements of future associated onshore development.	• Assist in understanding of environmental values and sensitivities. • Assist in identifying potential risks and impacts. • Help understand community issues and requirements.

8.4 Methods and tools

ConocoPhillips' consultation method for major capital projects has been adapted to support the achievement of goals within five stages of the OPP process:

1. Scoping – identification of relevant persons through mapping of potential impacts and risks to relevant stakeholder functions, interests and activities

2. Definition – framing the OPP risks and issues, supported by targeted engagement

3. Targeted engagement – early dialogue with relevant stakeholders based on the intention to develop the offshore resources and making information regarding potential development concepts available

4. Public comment – publication of information to be available to all relevant and interested stakeholders, as well as the general public, enabling provision of open feedback and consideration of issues raised during the OPP public comment process

5. Future consultation – commitment to ongoing engagement based on deepening understanding and relationships as well as consideration of new or additional interests and issues identified during the OPP public comment process, and through subsequent engagement on specific topics and activities.

The tools regularly used in support of this process involve a combination of planned and opportunistic engagement activities supported by a range of written communications. These tools comprise scheduled meetings held on an ongoing basis, targeted briefings, conference participation, speaking engagements, roundtable participation, regular telephone and/or email interaction, other informal engagement opportunities, letters, formal notifications, media statements, factsheets, and website updates.

Prior to the OPP public comment period, ConocoPhillips' understanding of stakeholder issues and concerns has been gained through early consultation around specific related activities and potential development concepts. The understanding gained by all parties has been further enhanced by the formal public comment period (**Section 8.6**).

Previous stakeholder feedback related to the potential development of the Barossa offshore development area has been recorded and stored in ConocoPhillips' secure management system. A record of all relevant meeting notes, phone calls, letter correspondence and email exchanges, along with copies of project letters and factsheets is kept and mapped to each individual stakeholder.

All information issued by ConocoPhillips includes dedicated project contact details (phone, email, postal, online) through which stakeholders can provide feedback. Correspondence also includes links to the ConocoPhillips Australia website, where additional information and fact sheets are also available.

Where a specific business activity is being supported, such as a drilling campaign or environmental study, ConocoPhillips follows up the distribution of information with phone calls to associations representing likely affected stakeholders and relevant government agencies. The purpose of the calls is to verify each stakeholder has sufficient information and time to provide feedback and ensure any additional consultation is completed.

At all times, ConocoPhillips maintains dedicated channels for enquiries, whether related to a project, activity or of a general nature. ConocoPhillips looks to address all correspondence in a timely manner, based on the complexity of the required response. This process, summarised in **Figure 8-1**, is consistent with the provision of an open feedback mechanism as defined within performance standards commonly adopted internationally by the oil and gas industry.

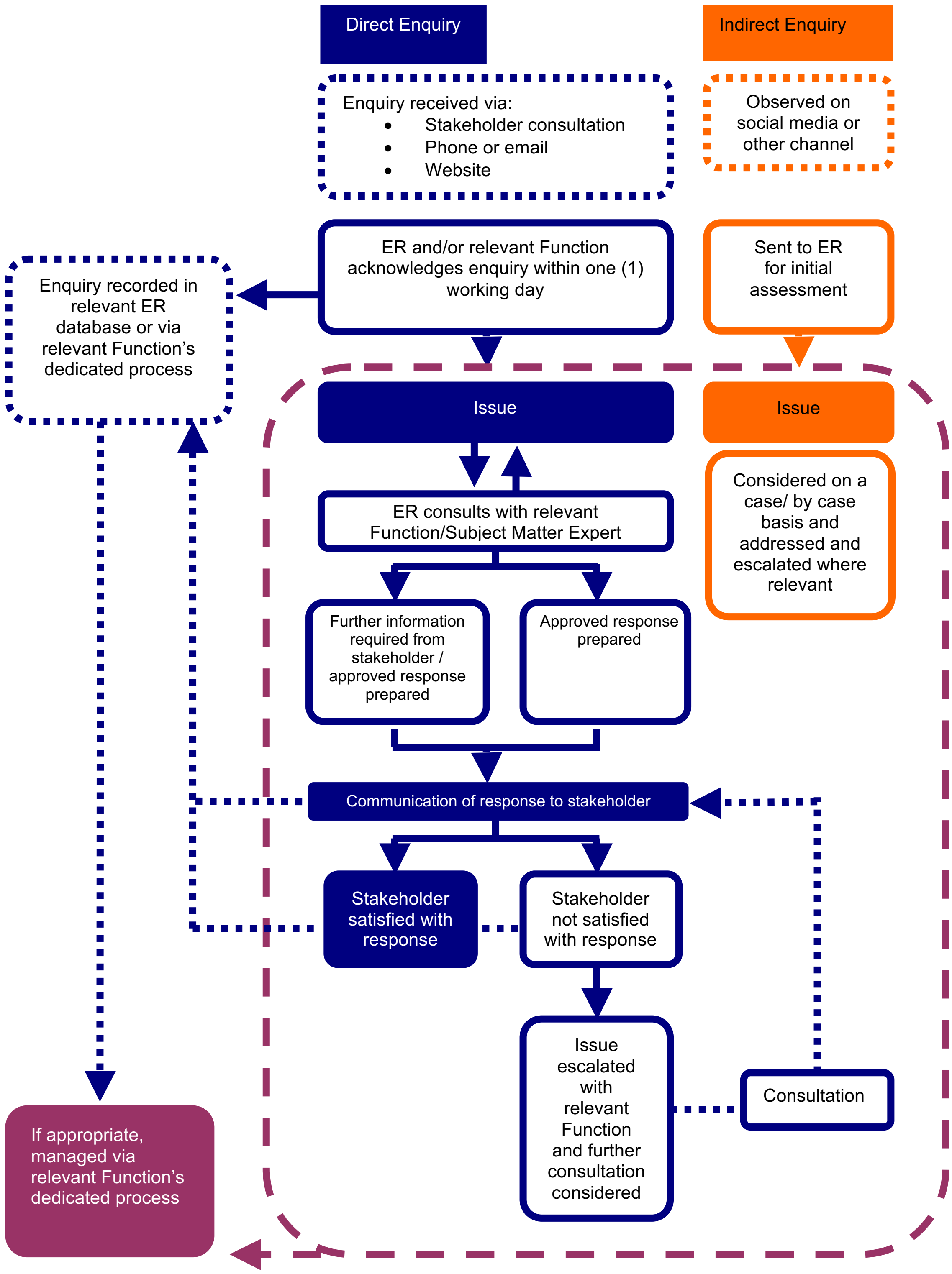


Figure 8-1: Stakeholder consultation and enquiry response flowchart

8.5 Activity and outcomes

Consultation relating to the potential development of the Barossa offshore development area has been ongoing since 2004. Engagement has focused on stakeholder awareness in relation to ConocoPhillips' environmental permitting, exploration and appraisal programs, and the potential for future development. This consultation has supported the following activities:

- environmental permitting during 2004/05 for exploration drilling program
- execution of the 2004/05 exploration drilling program
- environmental permitting during 2006/07 for seismic survey program
- execution of the seismic survey program during 2006/07
- environmental permitting and execution of the appraisal drilling program during 2014/15
- planning and execution of the Barossa marine studies program during 2014/15
- environmental permitting and execution of the marine seismic data acquisition during 2015/16
- environmental permitting during 2015/16 for additional appraisal drilling and execution of the program during 2017
- pre-OPP release consultation during Q2 2017
- formal OPP public comment period during Q3 2017.

In addition, during this period the potential for future development has also been discussed as part of ConocoPhillips' ongoing government engagement program providing regular activity updates to key ministerial offices and departments with the Australian, State and Territory governments. The program is conducted annually by ConocoPhillips and covers its operatorship of the onshore DLNG facility, the Bayu-Undan offshore facility and the Barossa, Caldita and Greater Poseidon offshore acreage.

Since mid-2014, following the introduction of the OPP process by the Commonwealth Government, Barossa stakeholders were advised of the new OPP process that would be involved should a development be pursued by ConocoPhillips. Engagement has included the provision of information related to the early feasibility and concept engineering studies of potential development options for the project.

In addition to the feedback received from these discussions, ConocoPhillips has also been able to draw on the knowledge and experience gained from its decade of stakeholder engagement with the community, industry and local, state and federal governments in Darwin and the NT, both generally and as operator of the offshore Bayu-Undan facility and onshore DLNG facility.

Combined, the above activities have resulted in an ongoing history of consultation with stakeholders relevant to potential future development of the Barossa offshore development area. As a result of this consultation, ConocoPhillips believes stakeholders have expressed the following broad opinions and understandings related to the Company's intentions:

- support development of the offshore fields as a future gas resource
- support development of the offshore fields as a potential option for processing at the existing DLNG facility
- support continuation of the economic and employment benefits that ConocoPhillips' presence has provided to Perth, Darwin and the NT for over a decade
- understand that a new gas source will be required to ensure continued operation of the existing DLNG train once the current supply (from Bayu-Undan) is exhausted
- understand that backfill of gas from the Barossa offshore developement area into DLNG would extend that facility's life.

8.6 Ongoing process

ConocoPhillips' history of consultation to date has been enhanced by the outcomes of the OPP public comment process. Combined with historical consultation, this provides the framework for ongoing evolution of the Company's internal Project Stakeholder Engagement Plan.

Further detailed analysis of potential project impacts on stakeholder groups and the resulting risks and issues will be undertaken as the project progresses through ConocoPhillips' internal project stage gates. Other specific engagement plans will directly inform and enhance this plan and future consultation activities.

Ongoing consultation will occur in five stages, linked to internal project planning, provision of further information, meeting stakeholder expectations and the regulatory activities involved.

a. Pre OPP public comment period

As part of the engagement on its most recent appraisal activities in the Bonaparte Basin acreage, ConocoPhillips advised all stakeholders that development will be subject to the OPP regulatory assessment process. During 2017, prior to the OPP being formally released for public comment, ConocoPhillips re-engaged with a range of relevant stakeholders, including government agencies and commercial fishing associations, to discuss the project's status and the formal OPP engagement process. The overall aims were to ensure the key relevant stakeholders continue to receive opportunity to provide comment and their expectations related to engagement will be met.

As part of the OPP's release, ConocoPhillips informed all relevant stakeholders explaining the formal process and where and how information was available to them.

b. OPP public comment period

ConocoPhillips publicly advertised that the Barossa OPP was available for an eight-week public comment period from 13 July to 6 September 2017, and communicated directly to its stakeholders. This information was also available on the NOPSEMA and ConocoPhillips websites.

Comments received from stakeholders during the public comment period have been taken into consideration in this revised version of the OPP submitted to NOPSEMA for Stage 2 assessment. This version of the OPP also provides a summary of all comments received and an assessment of the merits of all items raised and ConocoPhillips' response (**Appendix R**).

NOPSEMA published the OPP on its website with details of how to make a submission and issued a formal notification to its information service subscribers on 13 July 2017 announcing the start of the public comment period. ConocoPhillips supported this process by:

- publishing information on a dedicated OPP page on the ConocoPhillips Australia Website
- issuing its own media release which was distributed to 18 news outlets and posted to ConocoPhillips' Australia website
- advertising through a public notice in national and NT newspapers (The Australian, The NT News and the Litchfield/Palmerston Sun)
- providing direct email notification to the full stakeholder list comprising 195 individuals from 93 organisations
- sending letters directly to 50 NT commercial fishing licence holders
- phone communication to/with the Tiwi Land Council, NT Seafood Council, Northern Prawn Fishery, Australian Fisheries Management Authority, Amateur Fisherman's Association of NT, Department of Fisheries - NT, Commonwealth Department of Industry, Innovation and Science
- project representative in attendance at South East Asia-Australia Offshore and Onshore Conference (SEAAOC) held in Darwin, with factsheets available
- OPP process referenced in ConocoPhillips' ABU-West President's speech to SEAAOC attendees and request made for public comment on proposal
- re-advertising half way through the public comment period in national and NT newspapers
- sending reminder emails and letters to stakeholders (including NT commercial fishing licence holders) half way through public comment period
- briefing update provided to Amateur Fisherman's Association of NT.

The public comment period was managed within ConocoPhillips by the External Relations team with support from all involved functions of the business.

Five formal submissions were received before the close of the public comment period, and ConocoPhillips accepted an additional two late submissions. These seven submissions were received from the following individuals or organisations:

- The Sea Turtle Foundation
- The Director of National Parks, Australian Government
- The Environmental Defenders Office NT, on behalf of the Australian Marine Conservation Society
- The Northern Territory Department of Primary Industry and Resources
- The Northern Territory Department of Environment and Natural Resources and the Northern Territory Department of Tourism and Culture (joint submission)
- An individual, Michael Williams of MFW Consultants
- An anonymous submission.

Per ConocoPhillips' internal Stakeholder Engagement Plan, each submission received during the public comment period was formally logged and assessed by subject matter experts. Once the assessment had been completed and included in the summary report and other relevant sections of the OPP, a formal written response, including ConocoPhillips' assessment of merit and response, was also provided directly to the stakeholder, where contact details had been provided.

The full details of these submissions are included in **Appendix R - Summary Report,** including a summary of the comments made, a merit assessment of each item raised, ConocoPhillips' statement of response, and a description of any changes that have been made to the OPP as a result of these items raised.

Following the original submission of the OPP to NOPSEMA for Stage 2 assessment of acceptability, additional correspondence with stakeholders has been undertaken as follows.

1. Parks Australia provided further advice in relation to the comments made in the Director of National Parks' original submission and after discussion with Parks Australia, ConocoPhillips has revised its assessment of merit and response to the comments to that presented in **Appendix R**.

2. After the OPP was submitted for assessment, DoEE updated the National Conservation Values Atlas to include spatial data showing (draft) habitats critical to the survival of marine turtles called 'Marine Turtles – Habitat Critical (Draft)' (DoEE 2017d). As a result, ConocoPhillips re-evaluated its assessment of merit and response to the comments received during the public comment period that related to impacts and risks to marine turtles and has revised the OPP, including **Appendix R**, based on this re-evaluation.

Where revisions were made to the original assessment of merit and response, the revised information, as presented in **Appendix R**, were provided directly to the stakeholder that made the original comment to keep them updated with how their comments have been taken into consideration and addressed in the OPP. Parks Australia has responded to the revised information (presented in **Appendix R**) and stated that the amendments made to the OPP satisfy its concerns and reflect the intent of its feedback. Parks Australia also commented that reducing the area that the gas export pipeline corridor overlapped the Oceanic Shoals marine park is a positive outcome from a marine park management perspective. No further comments have been received from any other stakeholder.

c. Post OPP public comment period

As noted above, changes made to the final OPP as a result of stakeholder feedback were communicated directly to those stakeholders. In the event further changes to relevant areas of the OPP result, these will also be communicated to the stakeholder(s) concerned. All stakeholders will have access to the final OPP and summary report following formal acceptance by NOPSEMA.

Consultation with all relevant stakeholders, including those who have indicated their interest in the project will continue during the development of activity-specific EPs. The consultation process has been used extensively by ConocoPhillips for all its activities undertaken in Australia in compliance with the relevant legislation, regulations and guidance. The process used by ConocoPhillips will be further enhanced through NOPSEMA guidance and the APPEA Stakeholder Consultation and Engagement Principles and Methodology (draft, in preparation) once published.

The EP specific consultation process continues to engage a range of stakeholders, but concentrates on specific groups as relevant to that particular stage of development or activity. For example, consultation with the Director of National Parks will be ongoing throughout the preparation of EPs where a proposed activity is within or could impact on a marine park. Outcomes of all consultation are fully documented for provision to NOPSEMA and advice is provided to stakeholders on changes made as a result of their feedback. A summary is made available to stakeholders in the final, accepted EP summary.

d. Ongoing process during preparation of activity-specific EPs

ConocoPhillips will continue its ongoing, targeted consultation with stakeholders with direct interest in the proposed activities. Future consultation will take into consideration the additional stakeholders identified and issues raised during the OPP public comment period, as the project progresses.

ConocoPhillips has dedicated channels for enquiries and ongoing communication with all members of the public. The Company looks to address all correspondence in a timely manner, based on the complexity of the required response, and in accordance with the process outlined previously in **Figure 8-1**.

Complementing this process, ConocoPhillips consults on a regular basis with stakeholders who are either affected by development and operations or have an interest in these activities. For offshore activities, due to the remote location and minimal interaction with other users, consultation continues to principally occur with Government, the commercial fishing sector and other marine users. Other stakeholders with an interest in these activities are provided updated information and opportunity to comment.

ConocoPhillips is also involved in ongoing efforts by the industry, government and other relevant parties to improve the regulatory process governing consultation. These efforts occur on a Company to stakeholder basis and through collaboration with representative organisations.

e. Broader collaboration

ConocoPhillips consults on a regular basis with scientific and academic stakeholders to explore areas for collaboration and research related to its offshore permits. This broader commitment is evidenced by the ongoing involvement of ConocoPhillips and its key stakeholders in the Bonaparte Fish Group, established in 2013 to investigate research opportunities to advance understanding of fish and their habitats in the Bonaparte Gulf region.

Conceived as part of the baseline studies and stakeholder engagement activities, the Bonaparte Fish Group aims to:

- identify opportunities for collaborative research
- increase baseline knowledge in the area to inform environmental approvals
- collect data and information to inform fishery management strategies
- further develop stakeholder engagement.

To date, ConocoPhillips has undertaken collaboration on a gear trial with commercial fishermen in the Timor Reef Fishery and is currently finalising arrangements to contribute to a study to investigate stock structures of commercially valuable species across northern Australia in collaboration with the Fisheries Division of the NT DPIR, NT Seafood Council, WA Department of Fisheries, AIMS, Commonwealth Scientific and Industrial Research Organisation and Curtin University.

Given the ongoing appraisal activity and the potential for the project to proceed, ConocoPhillips is interested in continuing the engagement and collaborative approach to research and data collection and sharing in the Bonaparte Basin with the NT commercial fishing sector and Fisheries Division of the NT DPIR.

ConocoPhillips' interest in contributing includes its desire to:

- collaboratively collect data and information that can be used to inform management strategies that will ensure the long-term sustainability of the fisheries
- support access to the latest information and data relating to fish distributions and stock structure for baseline data to inform environmental approvals documents and contribute to adaptive management should any issues associated with project operations be identified
- continue to work collaboratively with other marine users in the Bonaparte region and maintain strong relationships across the industries.

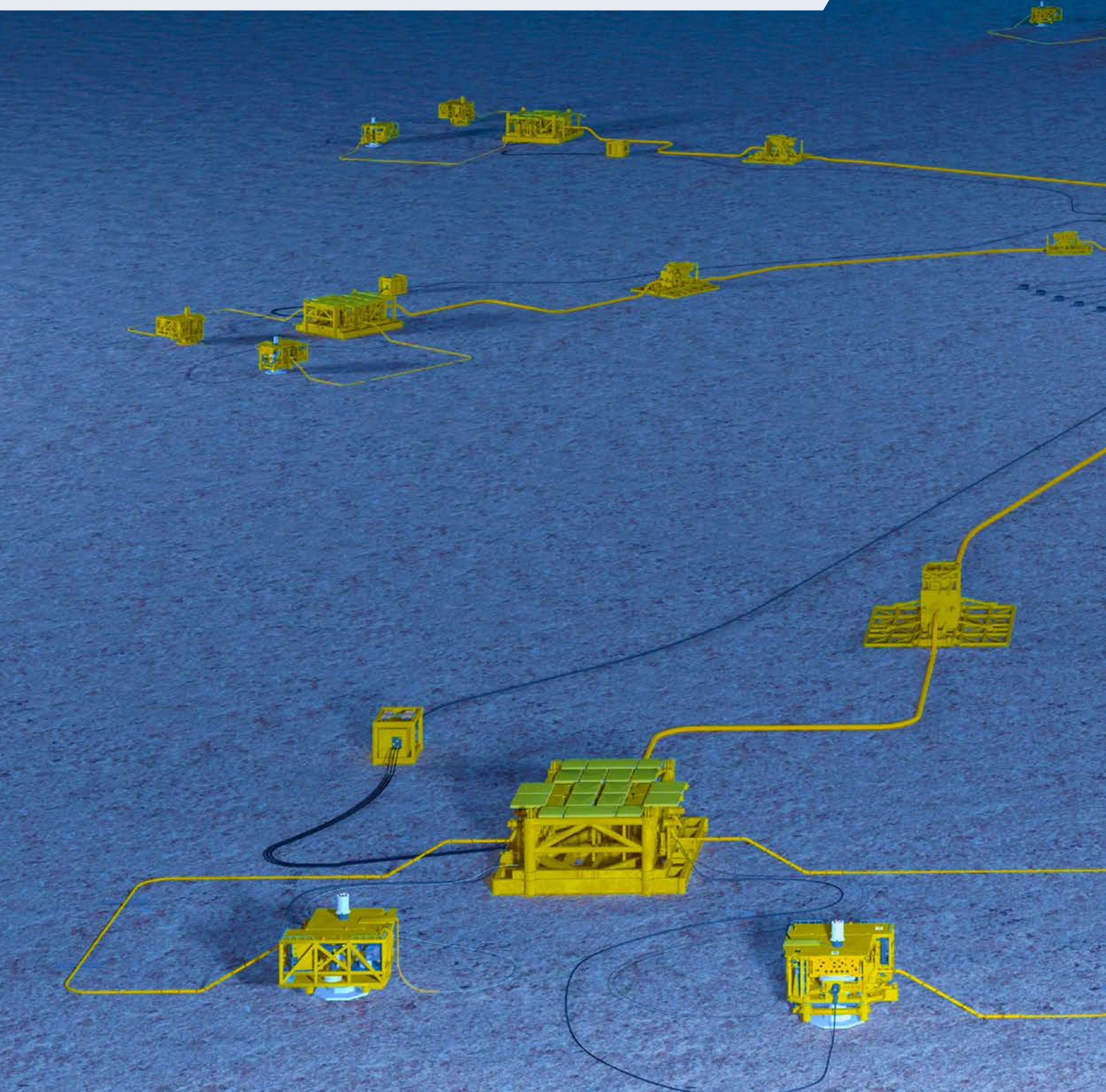
8.7 Conclusion

ConocoPhillips is committed to proactive and meaningful engagement with stakeholders as part of good business practice. This section demonstrates a process of continued engagement to seek input, views and perspectives as the project progresses. This consultation has been undertaken in different forms since 2004 and to date has indicated broad support for ConocoPhillips' intentions to commercialise its Bonaparte Basin acreage.

Based on the consultation to date, ConocoPhillips believes stakeholders support development of the Barossa offshore development area and the continued economic benefit it will deliver to Australia, in particular to the NT, and understand that a new gas resource will be required once the Bayu-Undan Field is exhausted. This understanding has been reinforced as a result of the formal public comment period which provided an opportunity for all to have their opinions and comments considered.

Consultation with all relevant stakeholders, including those who have indicated their interest in the project will continue during the development of activity-specific EPs.

9 References



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Appendices

Appendix A. Environmental legislation, regulations, standards, systems, practices and procedures

Appendix B. Water quality field survey report (Jacobs 2016a)

Appendix C. Sediment quality and infauna field survey report (Jacobs 2016b)

Appendix D. Benthic habitat report (Jacobs 2016c)

Appendix E. Underwater noise monitoring survey (JASCO 2016a)

Appendix F. AIMS regional shoals and shelf assessment (Heyward et al. 2017)

Appendix G. Drill cuttings and fluids dispersion modelling study (APASA 2012)

Appendix H. PW dispersion modelling study (RPS 2017a)

Appendix I. Cooling water dispersion modelling study (RPS 2017b)

Appendix J. Wastewater dispersion modelling study (RPS 2017c)

Appendix K. Dewatering dispersion modelling study (RPS 2017d)

Appendix L. Hydrocarbon spill modelling study (RPS 2017e)

Appendix M. Toxicity assessment of Barossa condensate (Jacobs 2017)

Appendix N. Underwater noise modelling study - FPSO facility anchor piling (JASCO 2017)

Appendix O. Underwater noise modelling study - FPSO facility operations (JASCO 2016b)

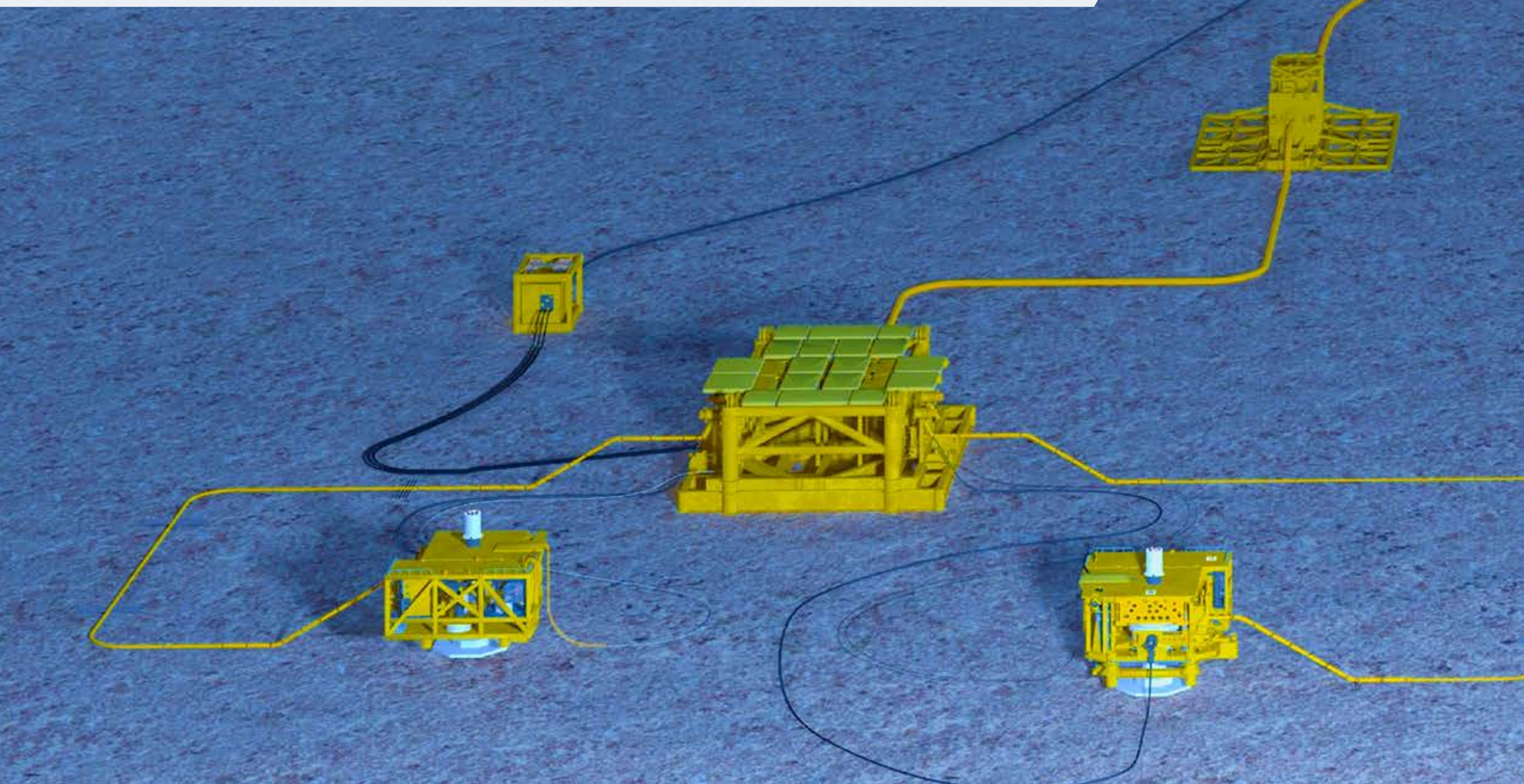
Appendix P. EPBC Act Protected Matters database searches

Appendix Q. Potential impacts of pipeline installation activities on marine turtles (Pendoley 2017)

Appendix R. Summary of response to submissions

All appendices cited in the Barossa Area Development Offshore Project Proposal (Barossa OPP) are located in the separate file, *Barossa Area Development Offshore Project Proposal Appendices*, which is also available on NOPSEMA's website,

https://www.nopsema.gov.au/consultation/OPP/3696



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